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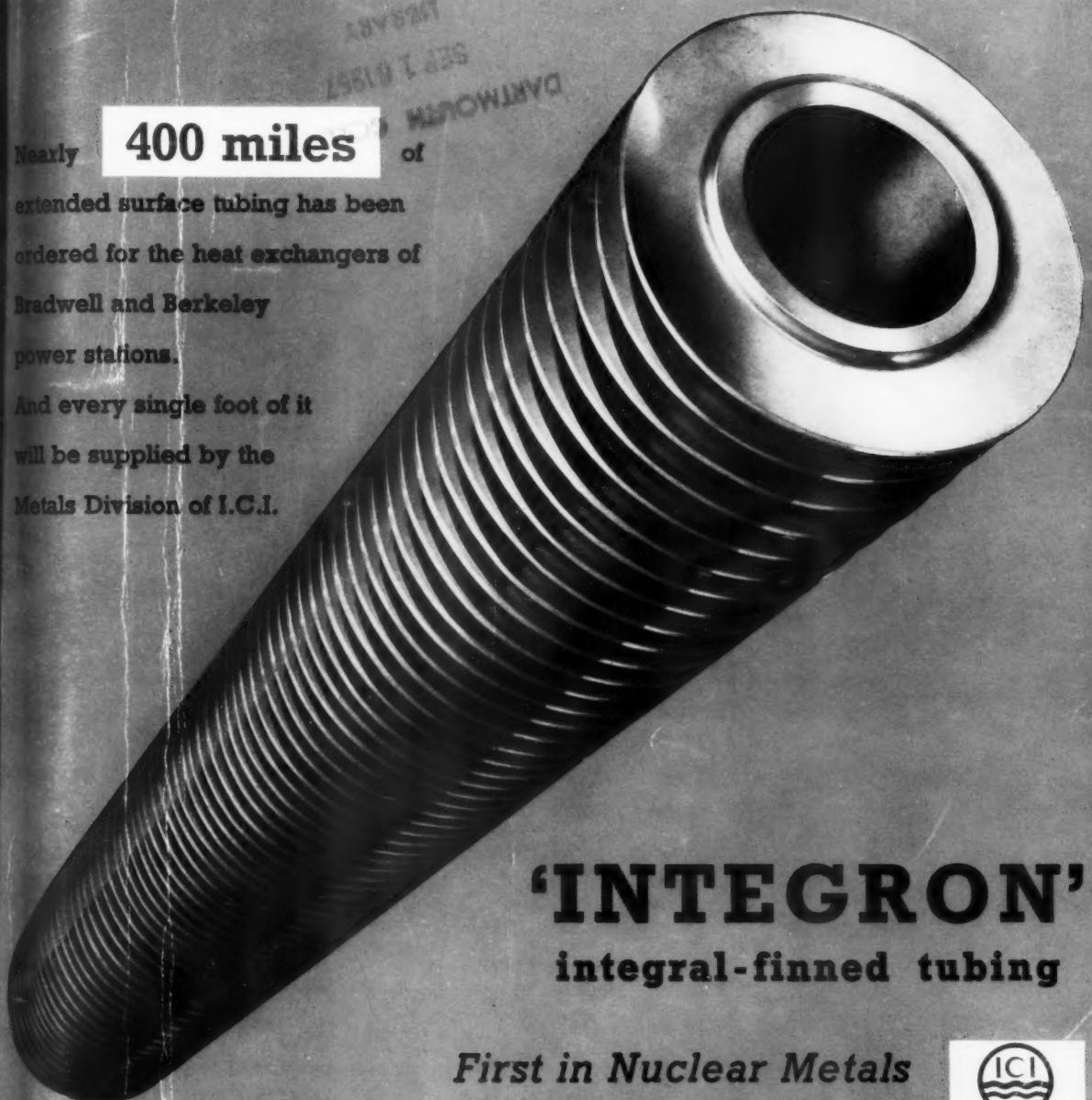

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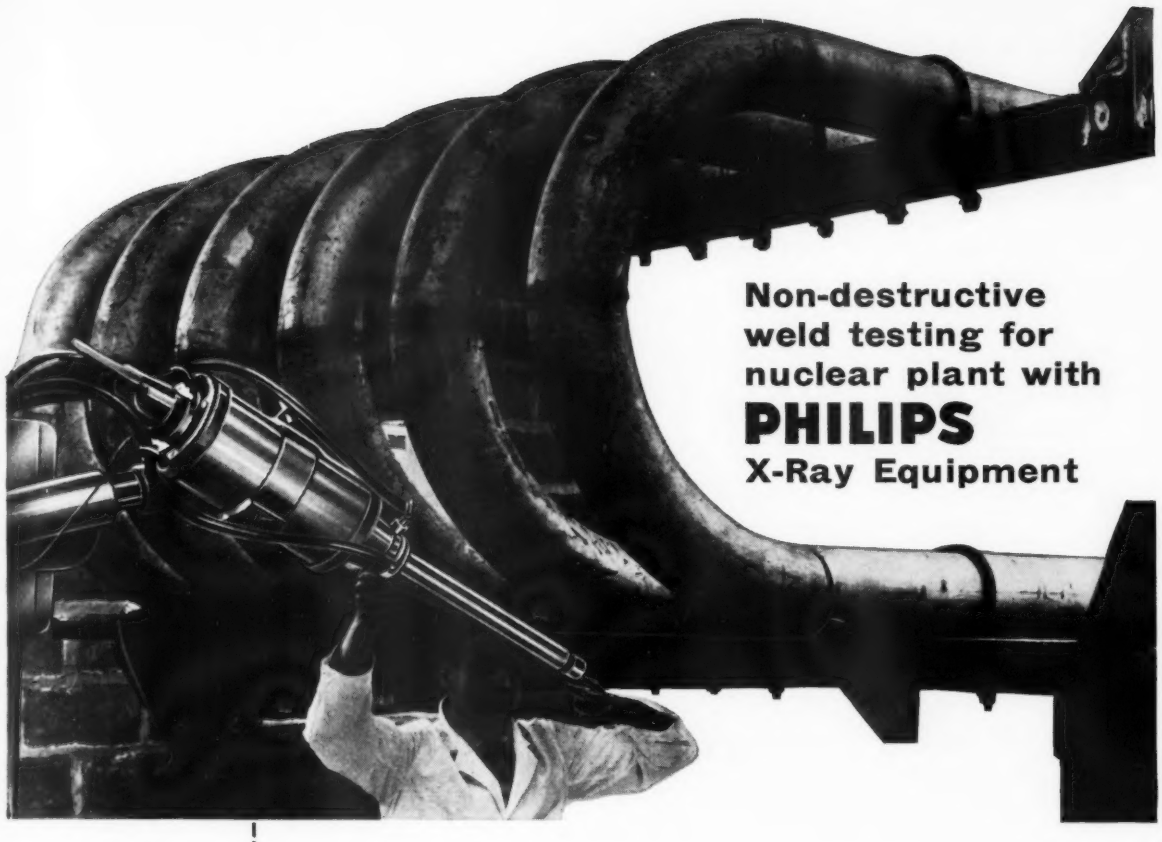

Non-destructive weld testing for nuclear plant with PHILIPS X-Ray Equipment

Philips portable Macrotank 'D' X-Ray Units are now in use on the inspection of site welding at Dounreay

Welded joints in this stainless steel pipework for liquid metal heat exchangers are here being inspected to extremely high standards with Philips X-Ray equipment. The heat exchangers, together with all liquid metal circuits, and principal vessels, are under construction by John Thompson Limited, Wolverhampton, for the U.K. Atomic Energy Authority's first full-scale breeder station at Dounreay, Caithness.

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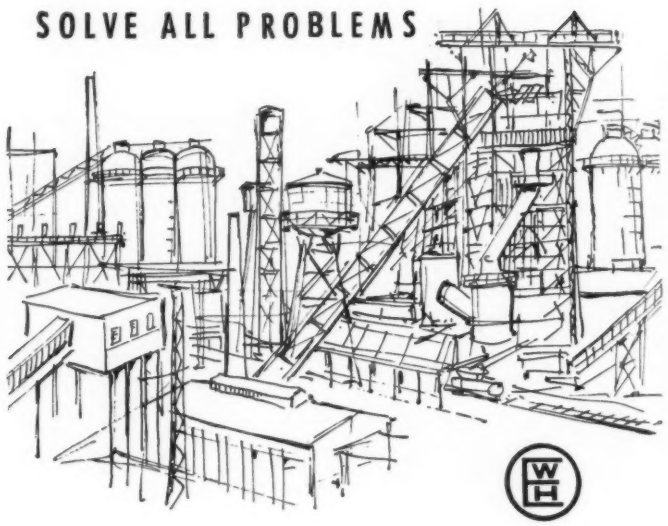

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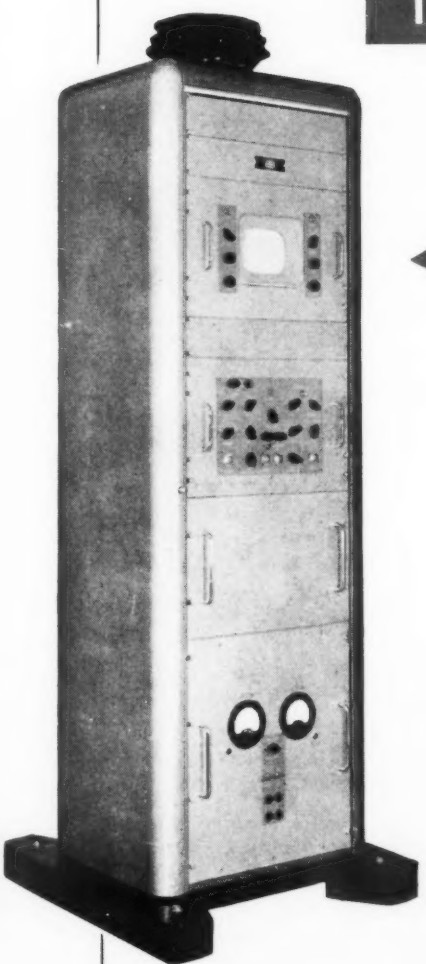

Pulse Height Analyser type PHA.2 for sorting a complex pulse amplitude spectrum into groups of known height. A random sample of up to 1250 p.p.s. can be analysed into 100 channels, each capable of counting more than 16,000 pulses, or into 70 channels of more than 1,000,000 pulses.

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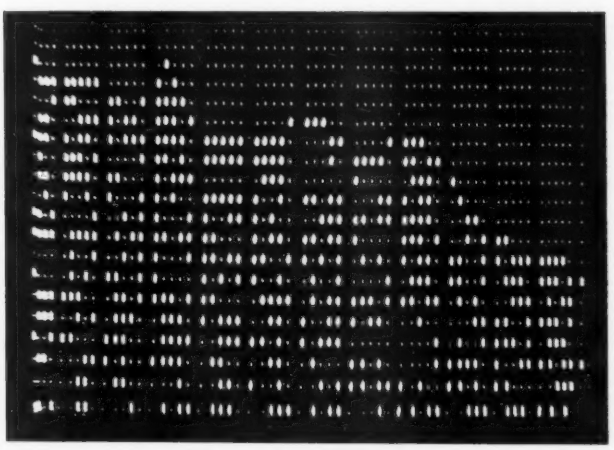

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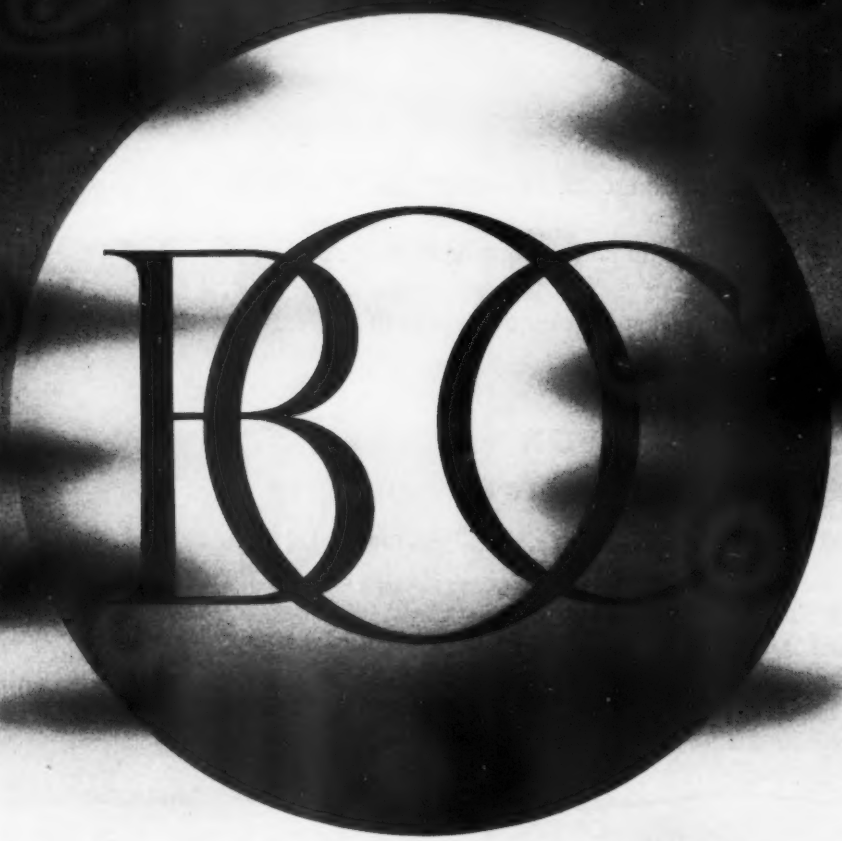

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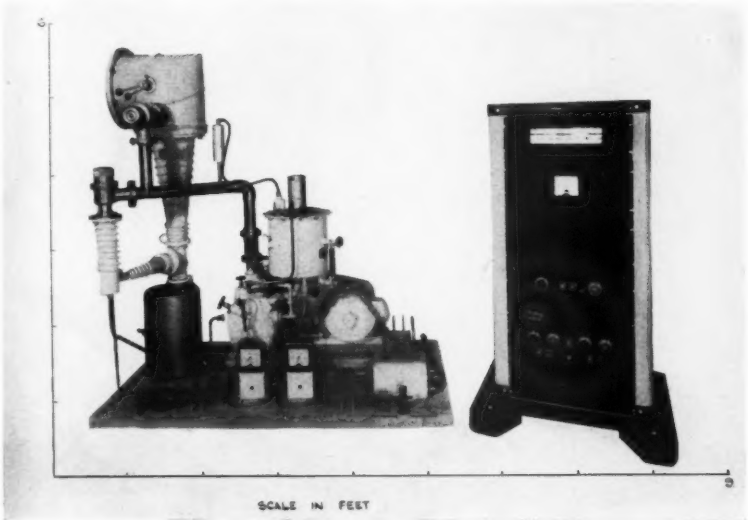

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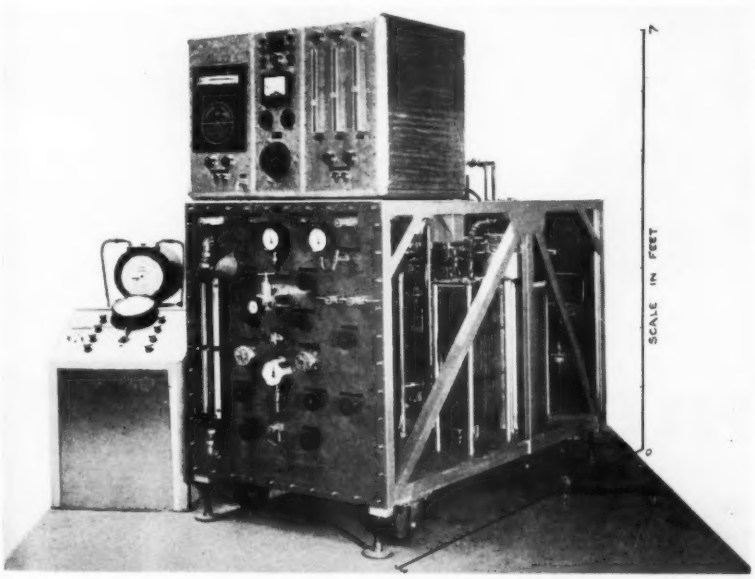

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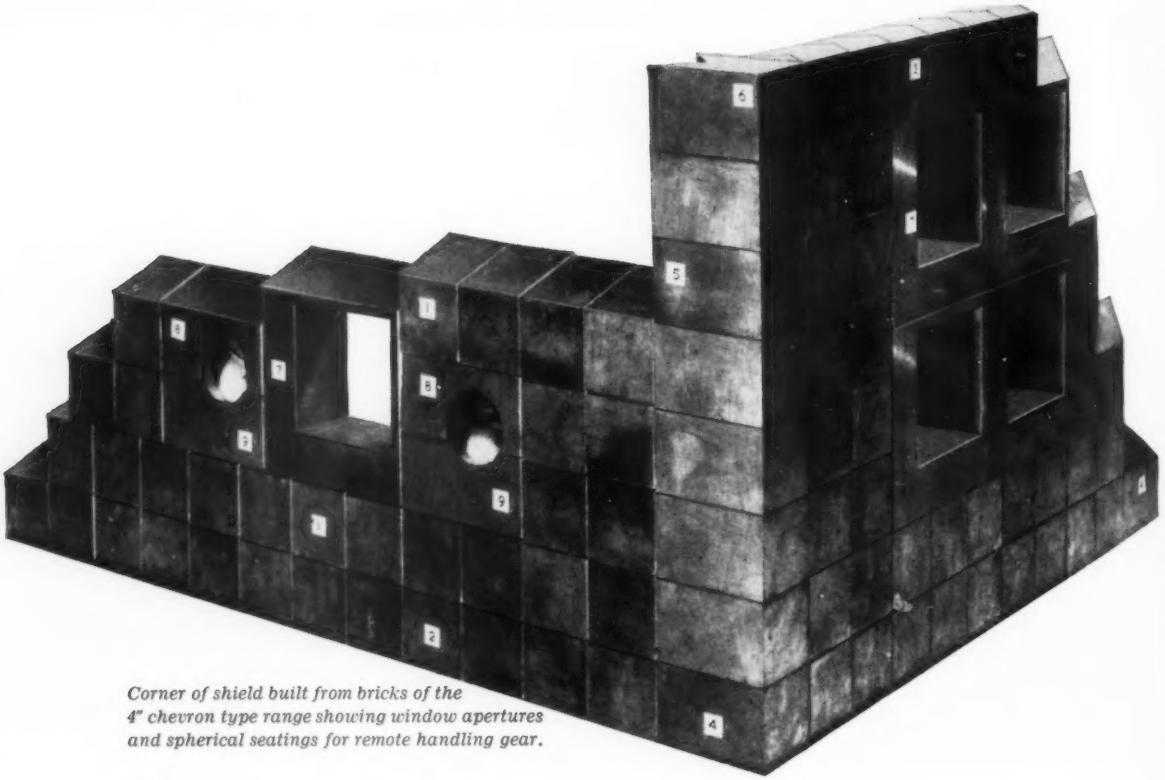
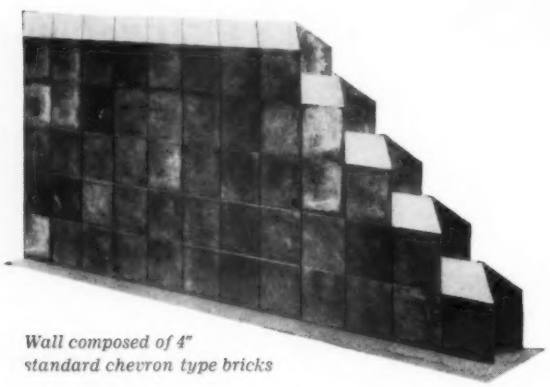


Corner of shield built from bricks of the 4" chevron type range showing window apertures and spherical seatings for remote handling gear.



Wall composed of 4" standard chevron type bricks

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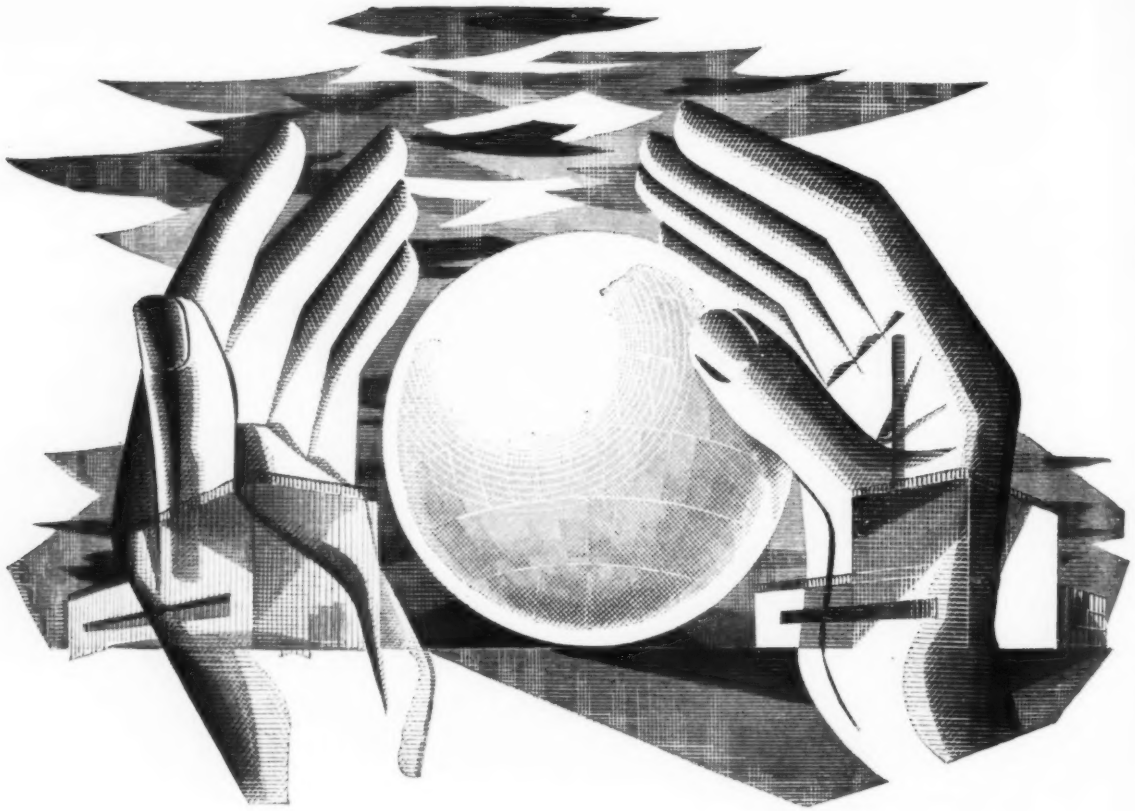

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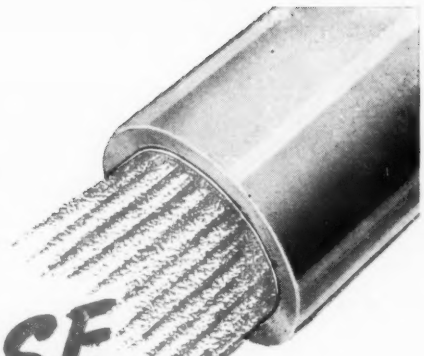

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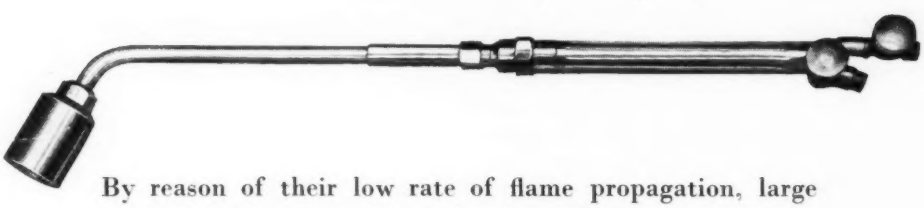

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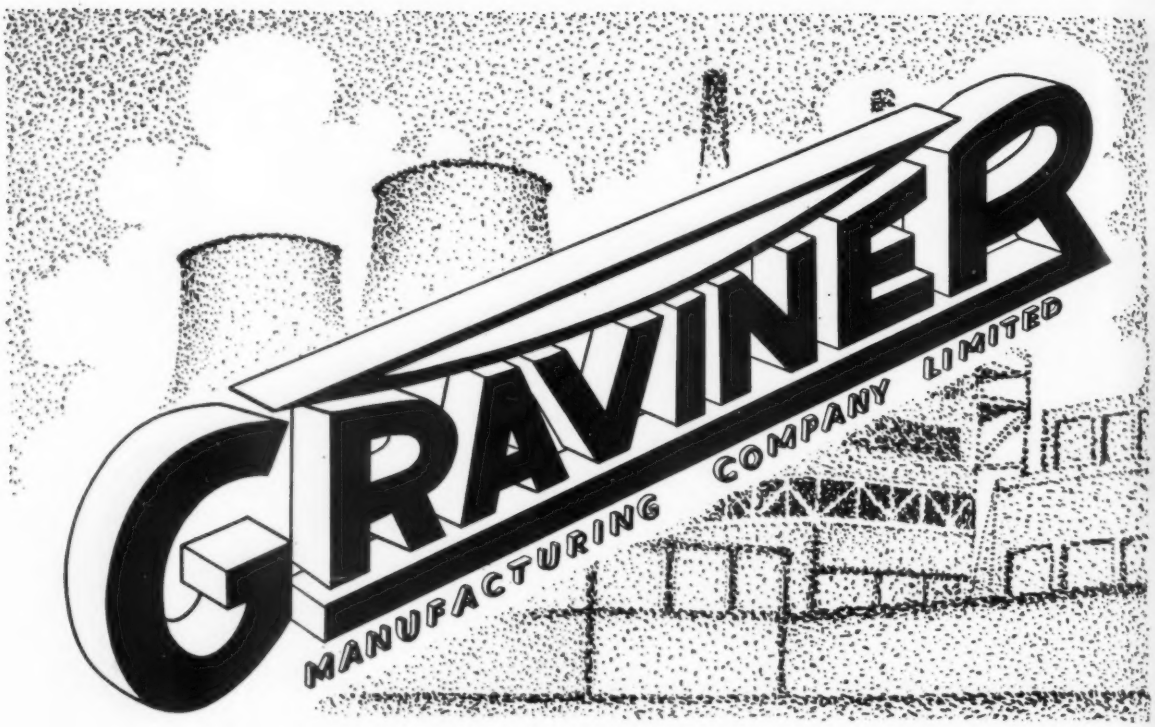

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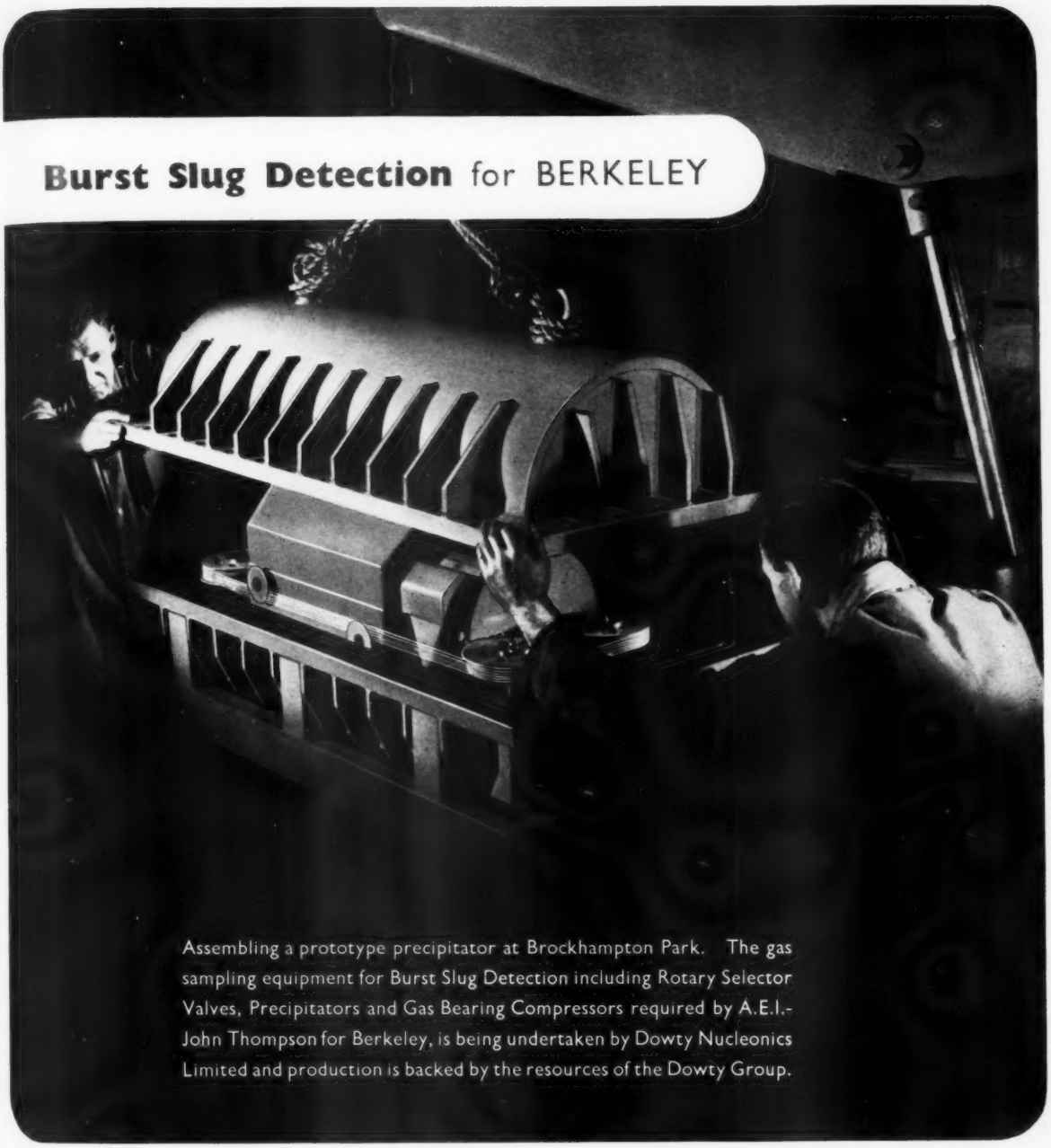

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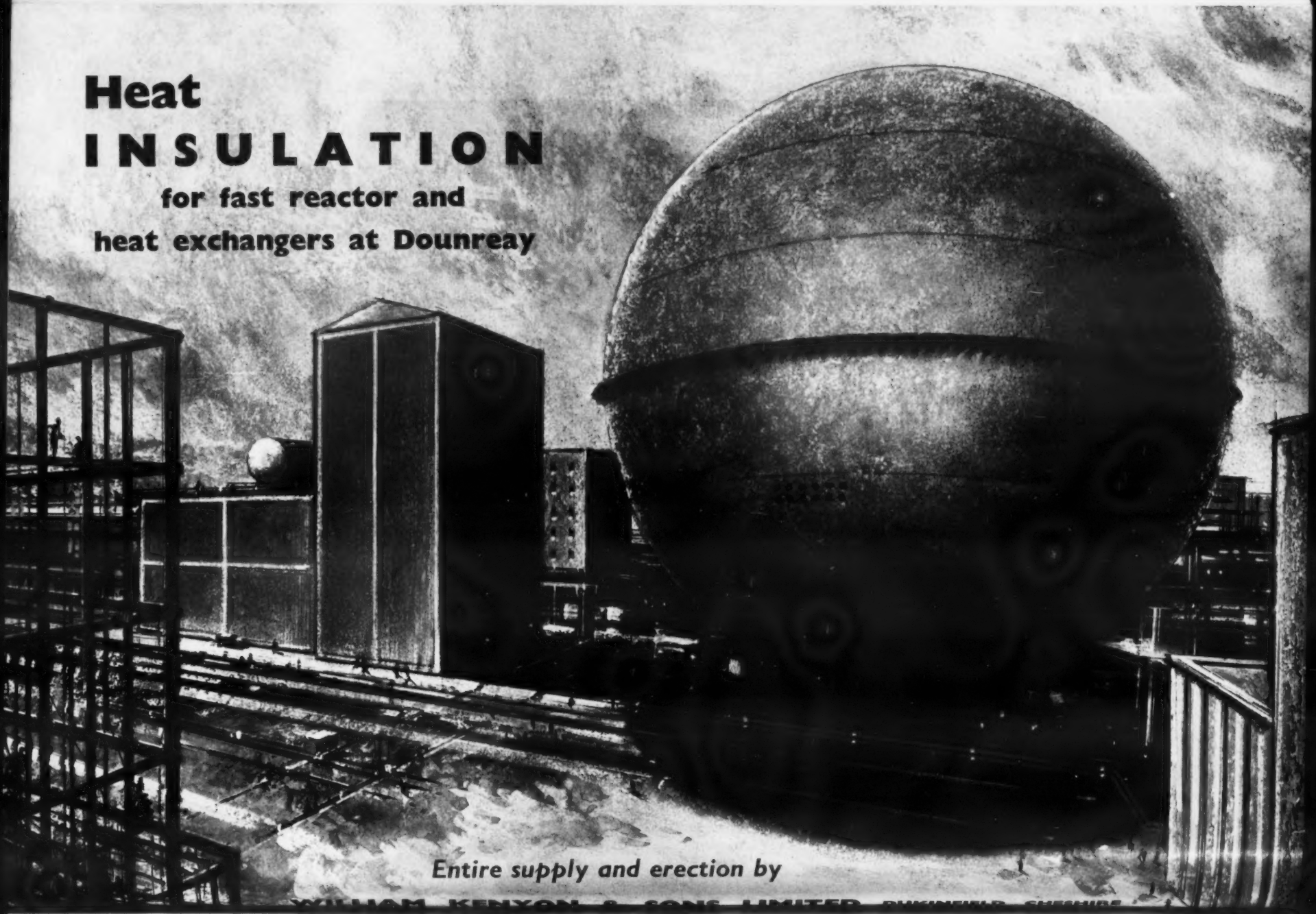

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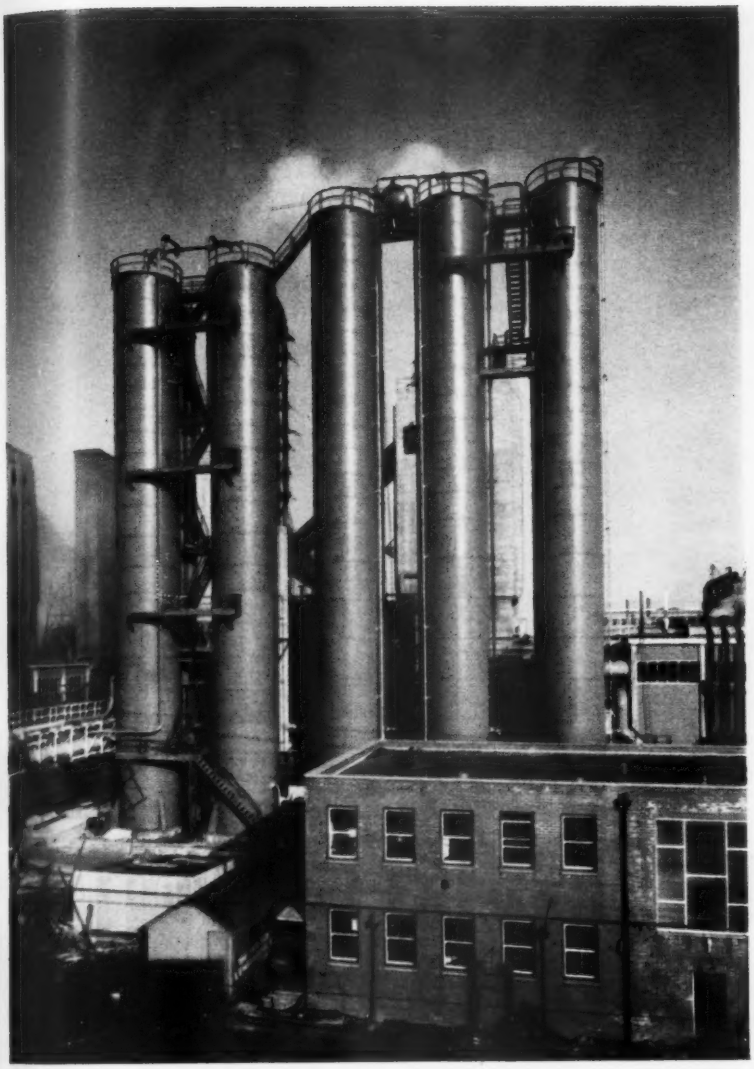

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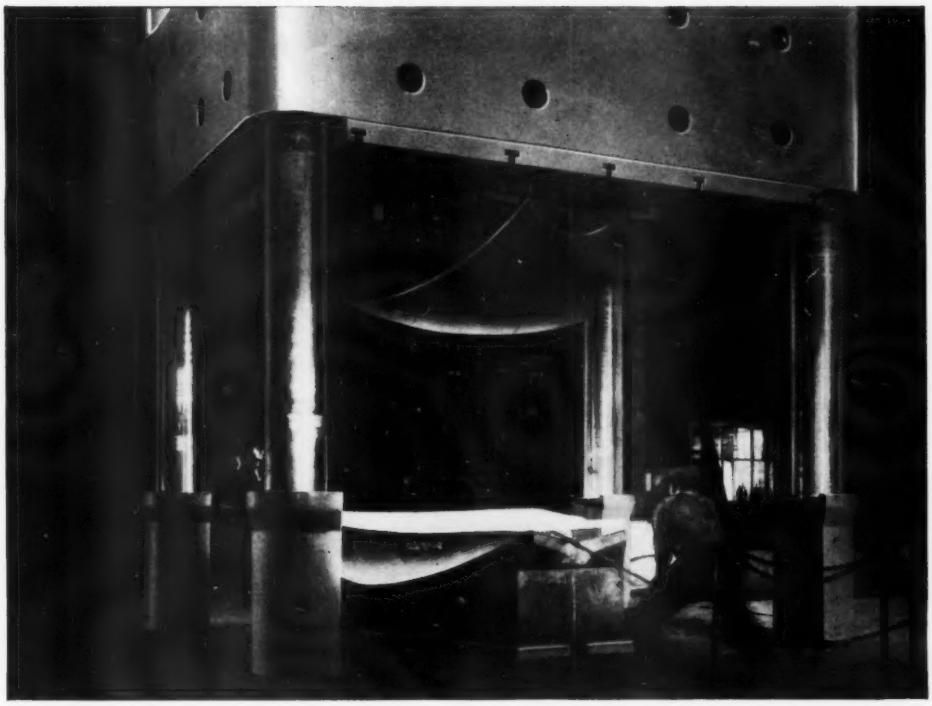

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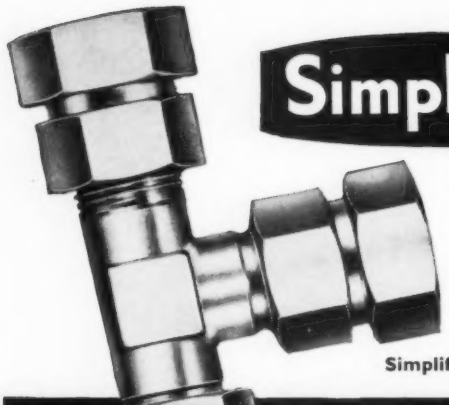

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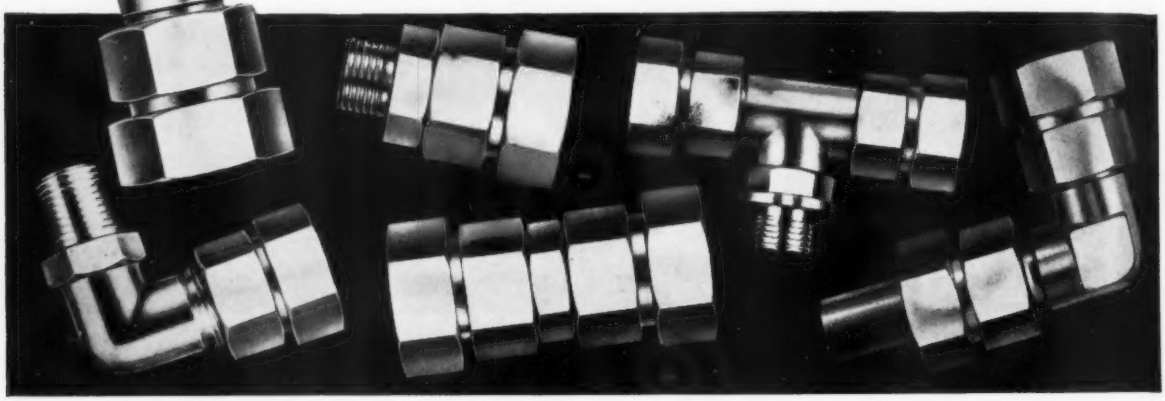

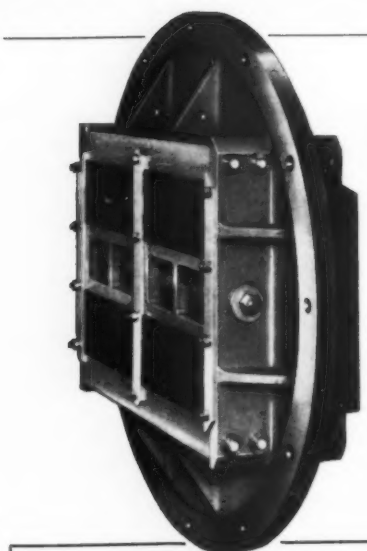

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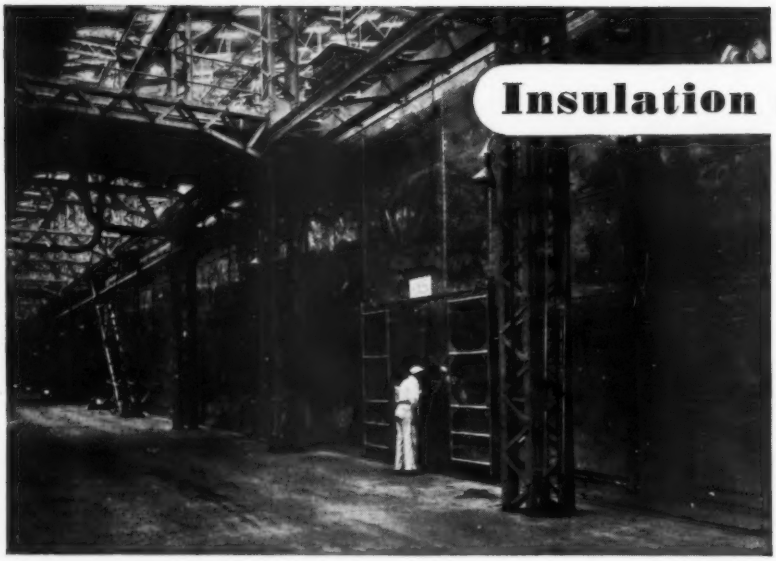

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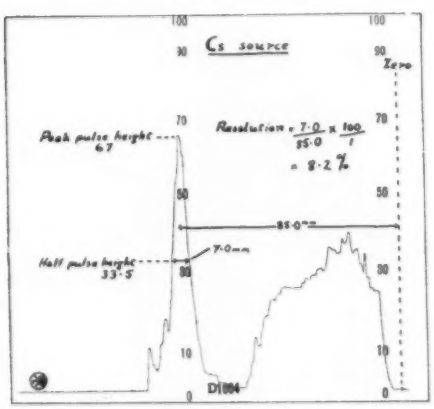

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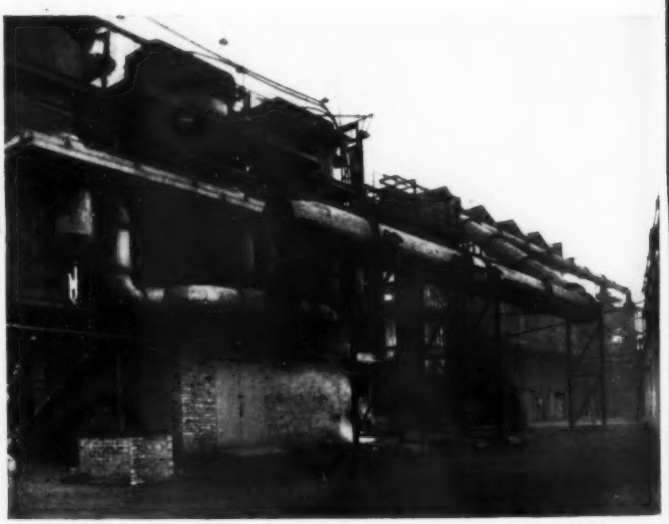

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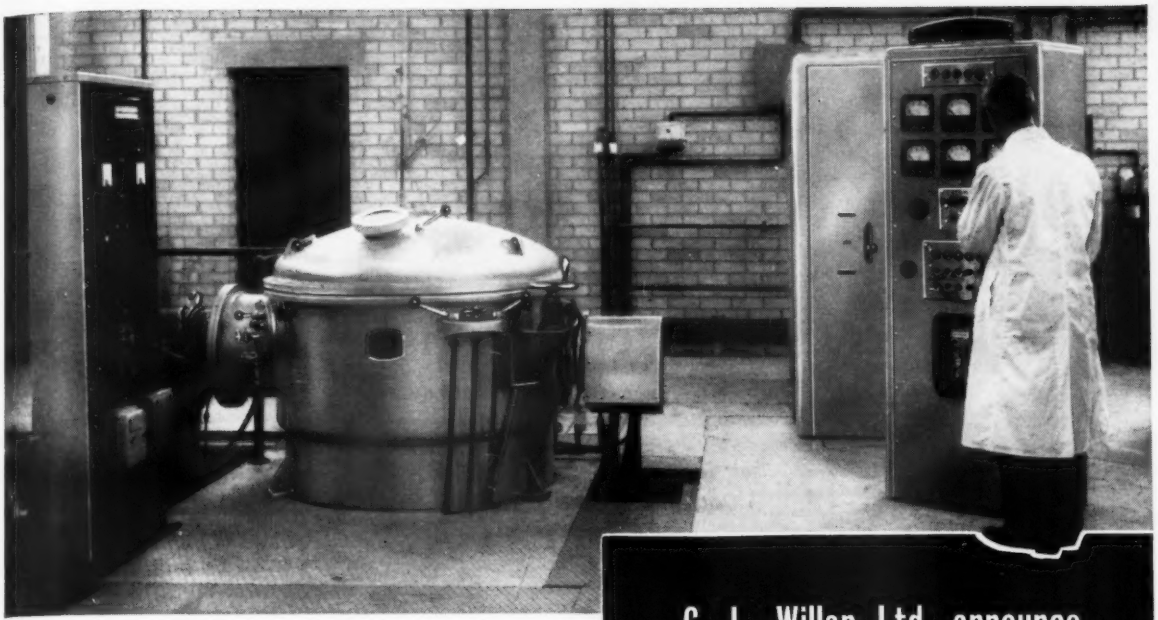

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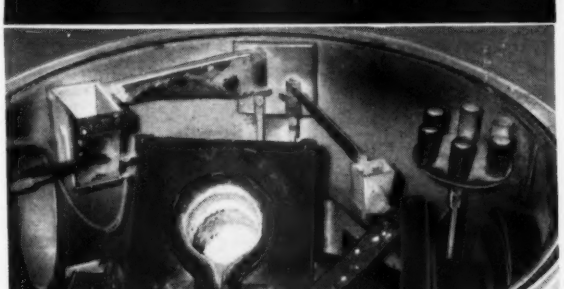

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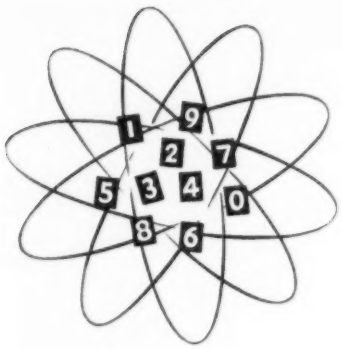

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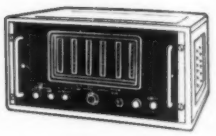

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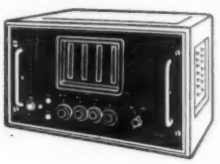

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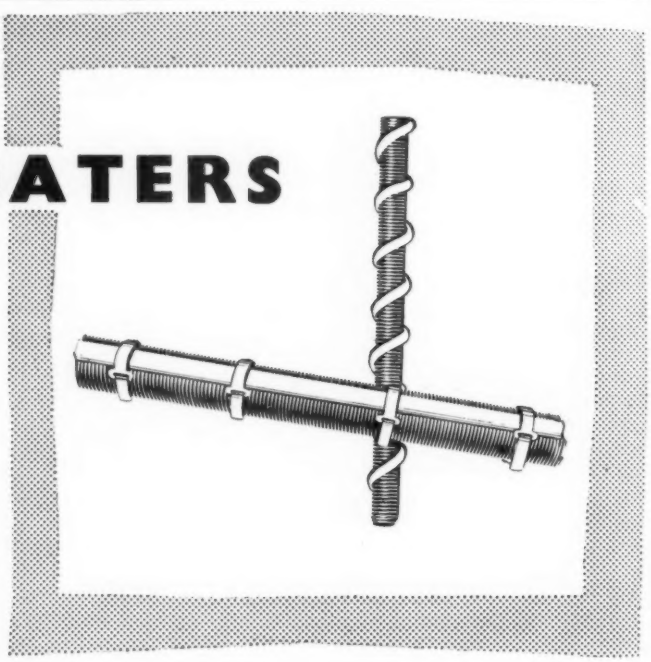

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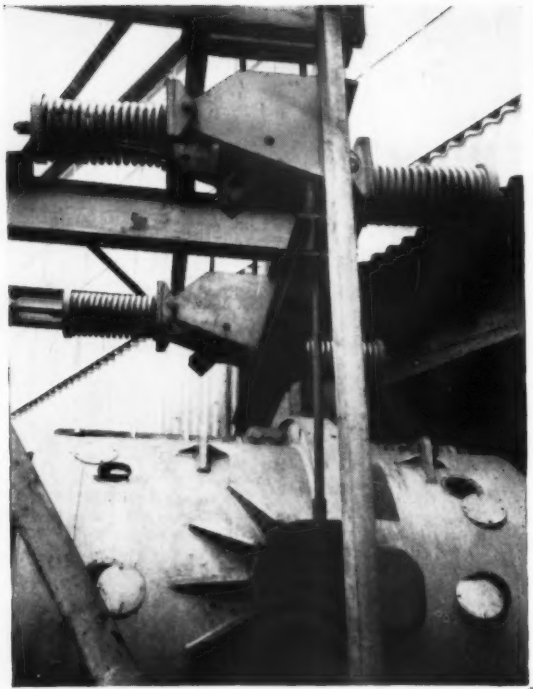

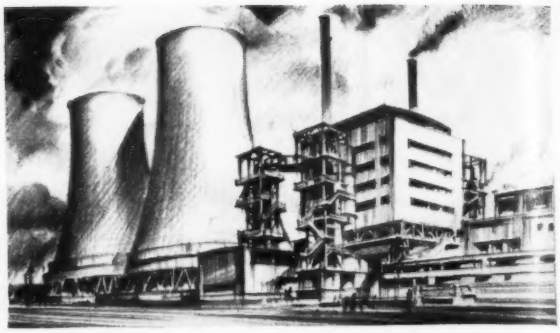

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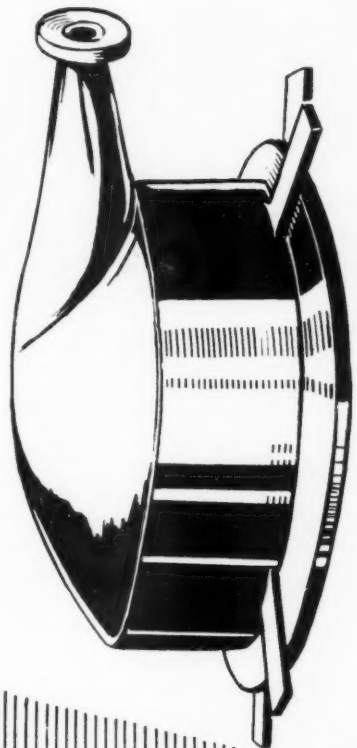

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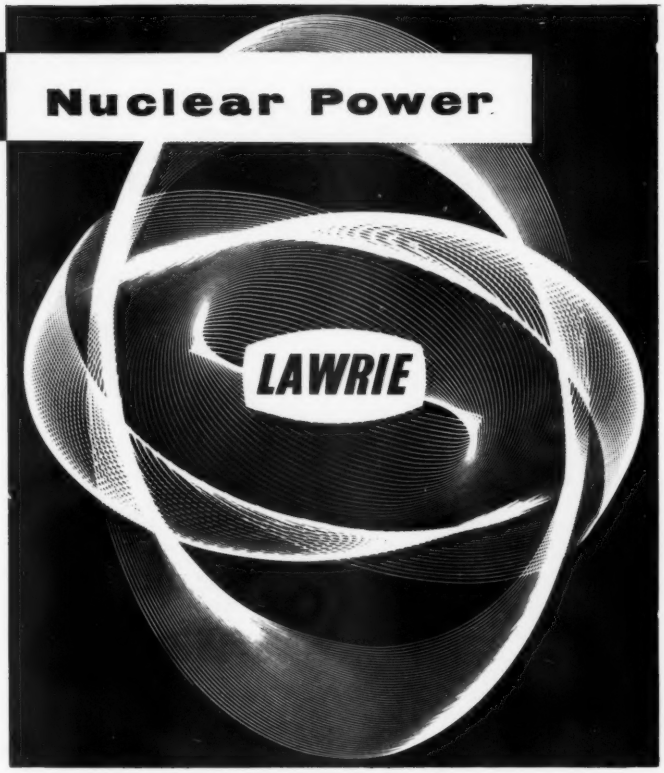

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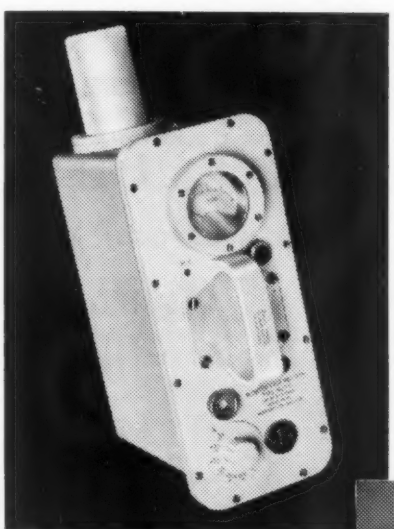

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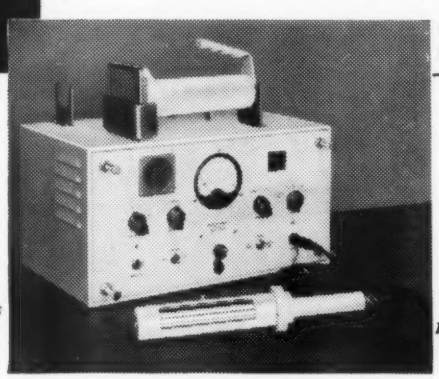

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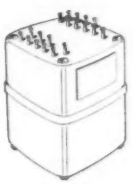

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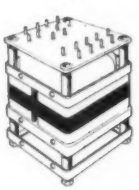

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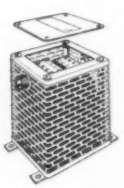

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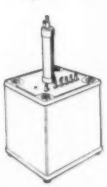

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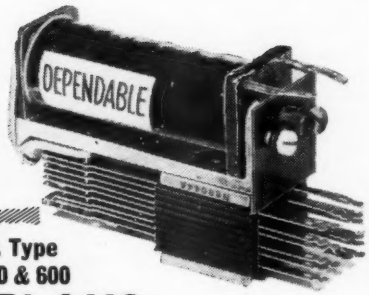

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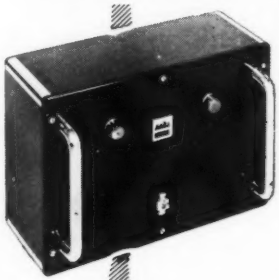

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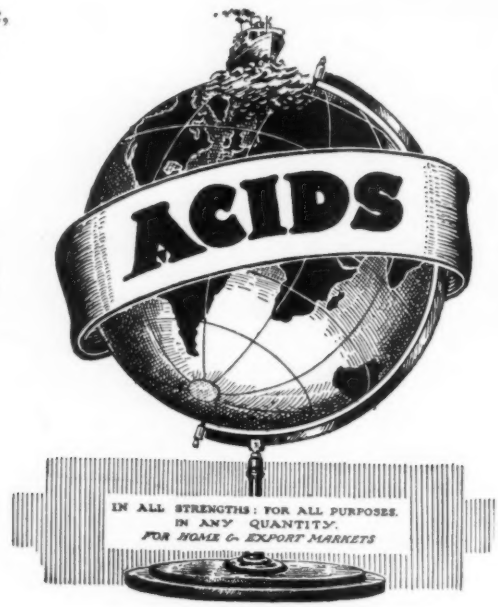

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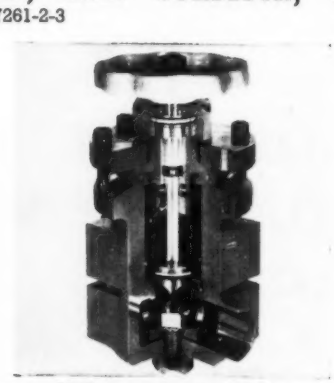

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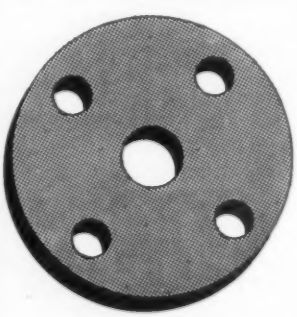

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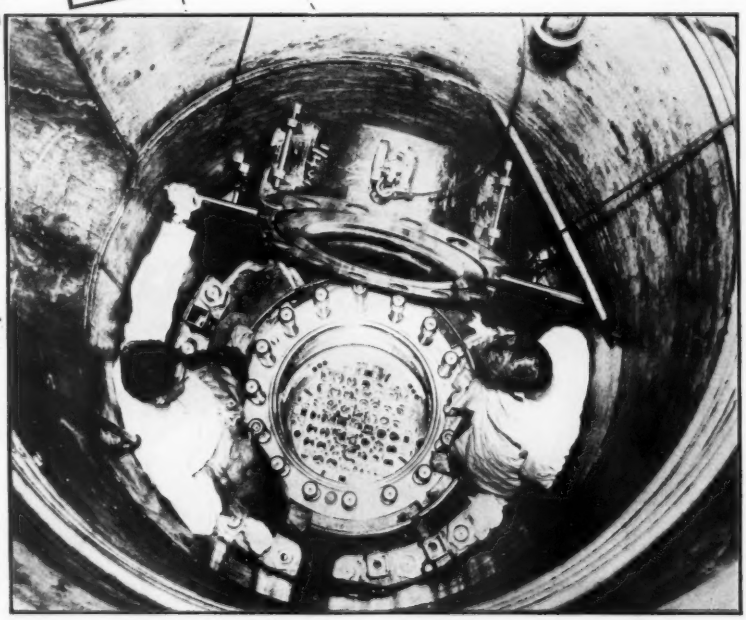

Overhead view of core structure in APPR-1 Reactor as technicians make final installation. Note 7 x 7 grid, with corners missing, that provides space for fuel elements and control rods.

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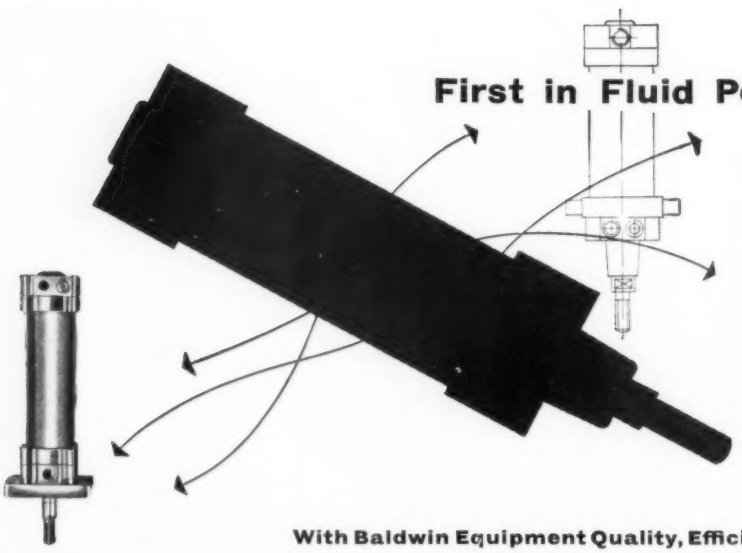

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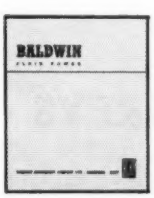

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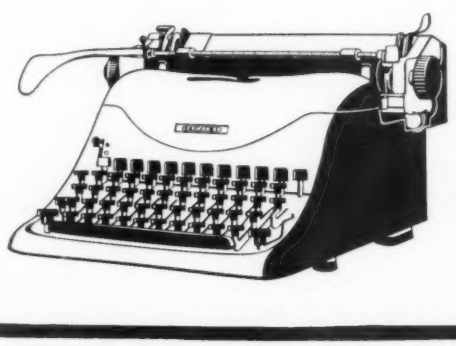

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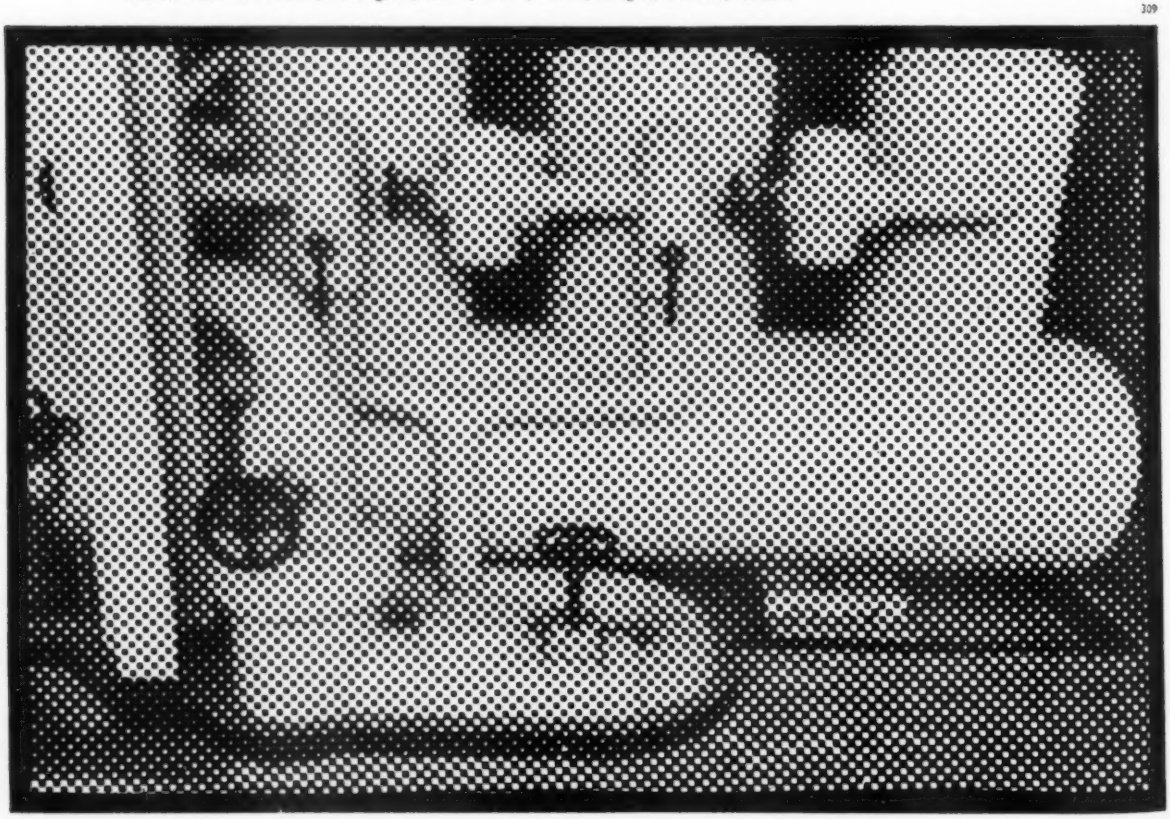

SEPTEMBER 1957 VOLUME 2 NUMBER 17

First with full details of the AMF-Mitchell closed-cycle boiling water reactor for Germany

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

In the control room of France's first nuclear power plant, G1 at Marcoule. Dials on the control desk are rod position indicators, graphic panel behind shows operation of whole plant at a glance. G1 is an air-cooled pile for producing plutonium but also supplies steam to a turboalternator (story p.356).

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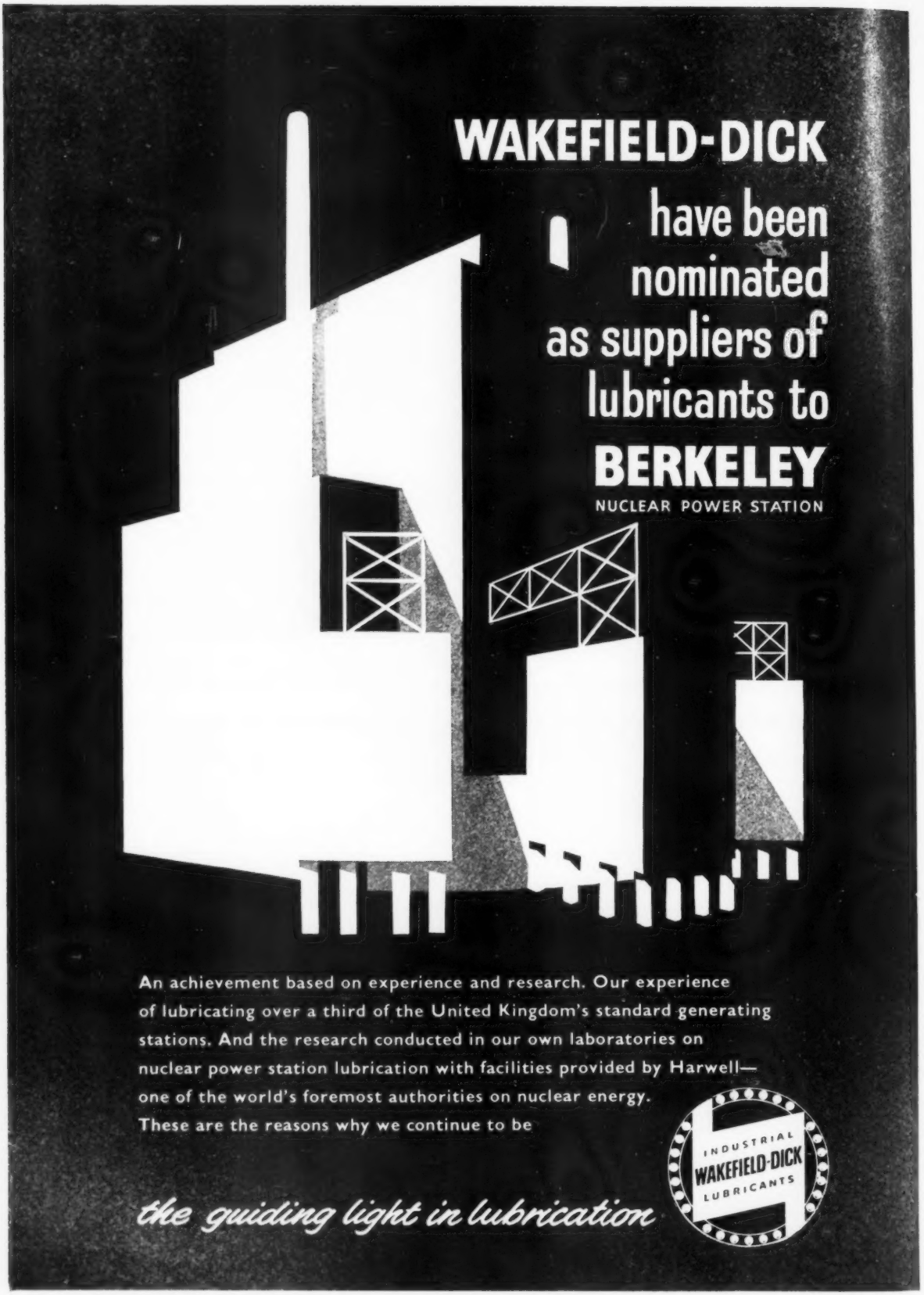
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Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING
SEPTEMBER 1957 VOLUME 2 NUMBER 17

La voie du plutonium

The industrial centre of France's Commissariat à l'Energie Atomique at Marcoule, now rapidly nearing completion, is a thing of justifiable pride among all young Frenchmen and has aroused admiration throughout the world. In post-war France, a country with a chronic economic problem and one with bitter memories of 1940, pride in technical achievement has become an important element in national life. Through it, it is hoped to solve the one and erase the other. Thus engineering accomplishments, like the transformation which has made French Railways probably the best in Europe, the magnificent hydro power schemes such as Donzère-Mondragon and jet aircraft like the *Mystère* and the *Caravelle* mean a very great deal to the French people. In the same category must be included France's outstanding contributions to the development of atomic energy—contributions unique among the big atomic powers in lacking the tremendous stimulus of a military commitment.

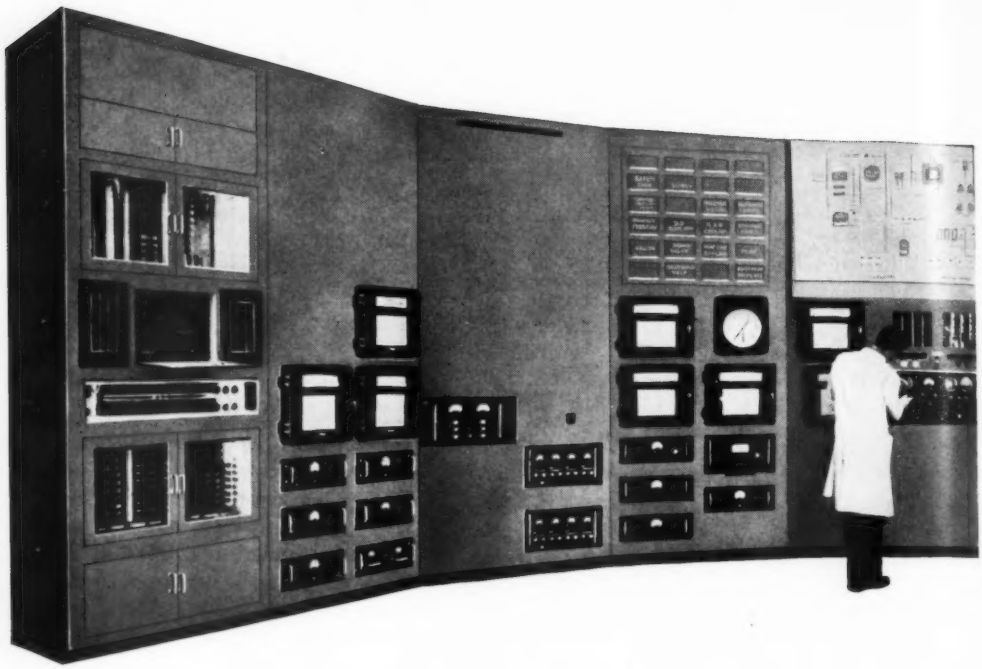
Ever since 1945 when Général de Gaulle, with a commendable depth of vision, set up the Commissariat, it has pursued an unswerving course which is now, 12 years after, just about to produce practical results. During those years the French scientists and engineers have pursued a lonely road but one which, now the wraps are off, is seen to be very similar indeed to the British one—with the big difference that France, having as yet no military programme has not invested in a diffusion plant. After a seven-year preliminary research and development era, she decided in 1952 to take *la voie du plutonium* and build as Stage 1 reactors, piles designed primarily for converting U-238 into fissionable Pu-239. This, then, is the role of Marcoule and its director Pierre Taranger has aptly compared it with a refinery producing aviation spirit from crude oil.

When the first French atomic five-year plan was begun in 1952, it had two main objects: the development of France's very considerable deposits of uraniferous ores and the creation of means to turn the resulting metal into plutonium. The first objective has now been achieved and output of uranium metal this year is expected to be 300 tons. The second aim is within sight of attainment and plutonium should start coming from Marcoule early next year.

Despite the fact that France has never announced any plans for bombs, she has not definitely renounced them as an instrument of national policy and it is probably that Marcoule's plutonium—100 kg a year—is of high Pu-239 purity, suitable for weapons. It is to be hoped however that this need will never arise and that the plutonium may go on quietly stockpiling until the French scientists have found a practical way of using it as an enriched fuel in power reactors.

Marcoule, like Windscale/Calder Hall, is not however just a plutonium factory but is also a power station in which Electricité de France will obtain valuable operating experience. Indeed comparisons with Calder Hall show a very close resemblance in performance despite the very different physical layout. What will be even more interesting however will be a comparison with EdF's first commercial power station at Chinon, for preliminary reports indicate a reactor layout very much more like Calder Hall than Marcoule.

France has just adopted a second five-year plan. This has only been outlined in very general terms yet and leaves unanswered the big question of whether she will or will not produce her own enriched uranium. Nevertheless the way in which the first plan has been fulfilled leaves little doubt that France knows where she is going and how to get there.



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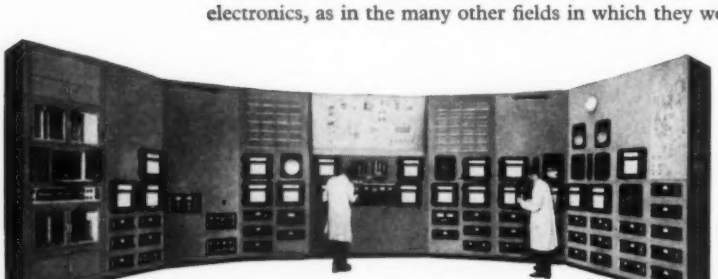

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Nuclear station for N. Wales

Proposed site for the fourth CEA nuclear station is at Trawsfynydd, Merionethshire, and early application for consent is to be made to the Ministry of Power and the local planning authority. Capacity of the station will be 400 to 500MW output and is planned for operation in 1962. Confirming earlier reports (*Worldview*, July) it will be connected by overhead line to the 275,000 volt transmission system at the Ffestiniog pumped storage station now under construction some five miles to the north.

The Trawsfynydd site is on the northern shore of a lake of the same name created thirty years ago as a storage reservoir for the Maentwrog hydroelectric power

Central Electricity Authority's fourth nuclear power station will probably be at Trawsfynnyd, N. Wales. Edern, to the west, is a possible further site

station. It is large enough to provide cooling water for a station up to 500MW. Rocky and broken, the land, owned by the CEA, has no agricultural value.

The CEA have also named another suitable site two miles west of Edern on the north coast of the Lleyn Peninsula, Caernarvonshire. Here the land is mainly rough heath and low cliffs. The sea is deep near the shore and the unlimited cooling water available may mean that the site will be used for an even larger station than Trawsfynydd. Timing of proposals for Edern will depend on system requirements and the scale of the whole nuclear programme.

Nuclear energy for teachers

A hundred teachers in universities and higher technical colleges from 14 European countries recently attended courses in nuclear energy organized, at the instigation of the OEEC and the European Productivity Agency, by Harwell and the Centre d'Etudes Nucléaires at Saclay. Aimed at assisting teachers in keeping up to date with the latest progress in nuclear techniques, the first course, for French-speaking teachers, began at Saclay on July 15. It was opened by Prof Perrin, High Commissioner for Atomic Energy, and lasted two weeks. A second course, for English-speaking teachers, was held at Harwell from August 6–16.

Nothing in it today—ship chief

Lots of people are making fools of themselves over the use of atomic propulsion for merchant ships according to reports of a speech made by Harland & Wolff 79-year-old chairman Sir Frederick Rebbeck at a launching from his Belfast yard last month. 'Something' he went on, 'is undoubtedly coming. But it may be a quarter of a century before you see anything very active going down to the sea. There is nothing in it today which would make us want to be one of those to cuddle up to someone else and spend a lot of money to find out how not to do it.'

New post for Sir Christopher

First chairman of the Central Electricity Generating Board—to be set up on Jan 1, 1958, under the 1957 Electricity Act—is to be Sir Christopher Hinton, KBE, FRS. This was announced by Lord Mills in the House of Lords last month, other appointments to the Board, which date from Sept 1, 1957, being: deputy chairman—Mr C. R. King, CBE; members—Mr F. H. S. Brown and Mr E. Long. Further names will be announced in due course.

Chairman of the new Electricity Council—the coordinating body for the whole supply industry—is to be Sir Henry Self, KCB, KCMG, KBE, with Sir Josiah Eccles, CBE, full-time and Professor R. S. Edwards, part-time deputy chairmen Lord Citrine, present chairman of the CEA will continue as a part-time member of the Council. Further appointments to the two new bodies will be announced 'in due course.' Salaries of the two chairmen will be £10,000 a year, the deputy chairmen receiving £7,500.

Sir Christopher Hinton's appointment, as the leading nuclear power expert in the country, to a post where he will be in charge of conventional power stations as well as nuclear indicates clearly the Government's outlook on the future of the electricity supply industry. Whether he will relinquish his seat as Member for Engineering and Production on the Atomic Energy Authority is not known but it might be assumed that he would at least retain a part-time seat to ensure the closest liaison possible between the two authorities. The desirability of this was stressed during the debate on the new Act.

Sir Henry Self, 67, is at present deputy-chairman of the CEA: Sir Josiah Eccles, 60, is the other present deputy chairman. Mr Brown, 47, was made chief engineer of the CEA earlier this year. Mr King, 62, is chairman of the East Midlands Board. Mr Long, 59, is the present secretary of the CEA.

Under the new Act, the Electricity Council comprises chairman, two deputies and up to three members. In addition the chairman of the Generating Board and two of his colleagues are *ex officio* members together with the twelve chairmen of the Area Boards. The Generating Board will have a chairman and from seven to nine members. Its job will be to develop and maintain the main generating and transmission system for bulk supplies to the Area Boards in England and Wales.

Hunterston to go ahead

Government approval of the 320MW power station on the Hunterston, Ayrshire, site for the South of Scotland Electricity Board was announced by Secretary of State for Scotland, Mr J. S. Maclay on Aug 1. The station will be built by the GEC Simon-Carves Atomic Energy Group at a cost of about £M37. When it is completed in 1961 it will supply about a quarter of the South of Scotland's electricity demand at that time.

A report on the public inquiries into this site was published on July 9 by the Scottish Home Department. This recommended to the Secretary of State that approval be given to the construction of the station on the Hunterston site and that a compulsory purchase order be confirmed for the land. The recommendation was however subjected to certain conditions regarding amenity and appearance questions and also nuclear safety. The objectors were given a six week period in which to appeal against the order.

VHT reactor for Winfrith

First reactor experiment at the AEA's new Winfrith Heath, Dorset, research centre will be a zero-energy revision of what has become known as the Fortescue reactor. Named after Dr Peter Fortescue (who writes on page 381 this issue) the reactor is based on a solid homogeneous core pierced by smooth cooling channels. Also known as the Very High Temperature reactor it will have no separate fuel elements as such and the fissionable material—probably enriched uranium (235 or 233) oxide—and graphite moderator will be combined. Last November, the

AEA Industrial Group Assistant Director of Civil Reactors, R. V. Moore, referred to this reactor in one of his papers to the BNEC Calder Hall symposium. According to Moore, gas outlet temperatures of 800°C should be possible with a fissionable material rating of from 1 to 2 megawatts per kilogramme, compared with the Calder figure of only 0·2. Spread of fission products through the system is likely to be a difficult problem but Moore said the incentive was very high since overall plant efficiencies could exceed 40 pct while the high rating would lead to a further reduction in capital costs compared with h.t. reactors with metal-clad elements. One advantage of the Fortescue reactor is that it offers a real possibility of a gas-turbine system.

Last month a contract for a large part of the design and construction of the zero energy assembly was awarded to the General Electric Co Ltd. This will be used to study the nuclear characteristics of the system and to verify design calculations before a power reactor experiment is started.

Dr Fortescue left Harwell last month to spend two years 'on loan' to the John Jay Hopkins Laboratory of Pure and Applied Science, San Diego, California, operated by General Atomics Division of General Dynamics Corporation. On Nov 1 last year GA's general manager Frederic de Hoffman stated (*Worldview* Jan, 1957) that the laboratory would include a solid homogeneous reactor experiment with fuel and moderator mixed in such a way that a large prompt negative temperature coefficient would be built in. This is part of a feasibility study contract GA hold from the AEC for a VHT closed-circuit gas turbine system for oil tankers.

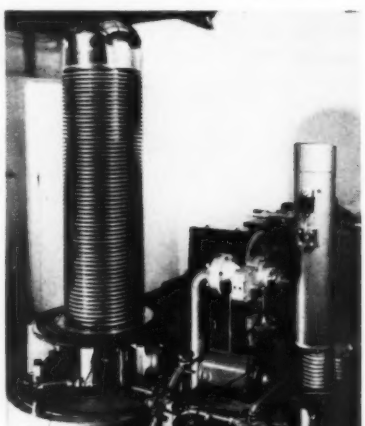
UKAEA loses Fermi case

Settlement was announced last month of a High Court case between Philips Electrical Ltd and the AEA concerning a patent taken out in Italy by Professor Fermi. This concerns the discovery, made by Fermi and his collaborators in Rome in 1934, that thermal neutrons are more effective in the production of radioactive elements than fast ones. The basic Italian patent was applied for in that year, the full title and all rights for most countries other than the US being subsequently acquired by Philips. A writ alleging infringement was served against the Authority in March 1956 by Philips, who at the same time applied for an extension of the patent. A compromise has been reached, and the terms of the settlement include the withdrawal of the extension petition and the payment of a sum to Philips by the AEA, believed to be around £10,000.

GERMANY

Van de Graaff for Cologne

E. Leybold's Nachfolger of Cologne recently put into operation in their workshops a 2 MeV van de Graaff generator of the type they now supply under licence from the High Voltage Engineering Corporation, Burlington, Mass. This will be used for experiments in association with their isotope investigation division, and



At Leybold's Cologne works a 2 MeV Van de Graaff machine has been installed. Of High Voltage Corporation design, it can be used for hard X-rays, monoenergetic electrons, neutrons or positive ions

their facilities will be available to assist research generally on the Continent. The official opening was attended by many prominent members of German industry, representatives of the German Atomic Energy Commission and Ministry of Supply.

New plan for 2000 MW

Eight nuclear power stations with an aggregate electrical output of 200 MW is now being mentioned by Federal Government spokesmen as being the probable scale of the programme to be carried out by 1967. In addition it is possible that eight powerful research or test reactors might be built during the same period. This apparently supersedes the programme put forward by Minister of Atomic Affairs Siegfried Balke last May when he mentioned the modest figure of 500 MW as a likely target. Clearly, however, Germany's contribution to the Euratom Plan must be of the order of thousands of megawatts if the scheme is to achieve its 15,000-by-1965 objective.

Reports from Bonn suggest three 100-150 MW power plants to British and American designs in the period 1959-63, similar sized reactors but of German design for 1961-65 and very much larger plants also of German design for the years 1963-67.

German experts believe the State must contribute to these plans—particularly in the matter of insurance cover—but they are insistent the Government interest shall not be controlling. Meanwhile the Government's atomic energy Bill is still in political difficulties and subject to a good deal of inter-party manoeuvring. One matter of controversy is the division of responsibility between the Federal and state governments.

ITALY

Nuclear station for South

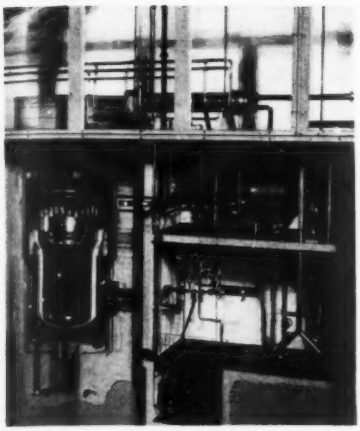
In cooperation with the Italian government, the World Bank is to invite tenders from manufacturers in Britain and the US for a 150MW nuclear station for Southern Italy. To be known as Project ENSI (Energia Nucleare Sud Italia), the study will include the selection of a suitable site, the preparation of invitations for tenders to qualified manufacturers on an international basis, a review of the tenders submitted and the preparation of their evaluation. The UKAEA and USAEC have agreed to provide nuclear engineering consultants for the project for the technical review of natural and enriched uranium tenders respectively. Their report and the tenders will be reviewed by an international panel of experts under a Canadian chairman to be set up by the World Bank. They will in turn report to Società Elettronucleare Nazionale for the final choice.

This announcement coincides with the news that Italian negotiations with the AEA for the purchase of a gas-cooled reactor have been successfully concluded. Value of the agreement, not yet finally signed, is between £M20 and £M30. America is also to supply a pressurized water reactor for Southern Italy by a contract signed by the Vitro Engineering Company and the government-owned Società Italiana Meridionale Energia Atomica (SIMEA). Total cost of this project is estimated at $M46; start-up is scheduled for early 1962. Components and services will be procured in Europe wherever practicable.

NORWAY

British fuel for Halden reactor

Cooperation between the UKAEA and the Norwegian Institute for Atomic Energy on the Halden reactor project was agreed last month. The Authority will provide the initial fuel charge of uranium elements for the reactor and will work with the Institute on a research programme to develop suitable elements for



Seen at Het Atoom exhibition in Amsterdam, cutaway model shows Norway's Halden reactor. Britain will supply fuel for this boiling heavy water plant

later charges. In exchange, the AEA will have access to the reactor design and operating experience.

Due to start operation in 1958, the reactor is a boiling heavy water power reactor built by IFA largely for experimental purposes. However, it will also supply steam at 220°C and 35 atm to an adjoining paper and pulp factory, which will be the first time reactor heat has been utilized directly. Interesting feature is that the reactor hall is tunnelled in solid rock in a mountainside, giving natural shielding.

SWITZERLAND

CERN cyclotron gives 600MeV

The synchrocyclotron built by CERN at Meyrin, near Cointrin airport, is now working at full strength. Professor W. Gentner, who is in charge of the project was able to do runs with the machines at its peak energy output of 600 MeV. In the near future, it will produce high energy protons for nuclear bombardment. The result of just over two year's intensive work, the machine is a landmark in international scientific cooperation—twelve countries are sharing the cost. Scientists from non-member countries are invited to participate in the research. Also at Meyrin, a 25,000 MeV proton synchrotron is under construction, and when completed late in 1960, this will be the largest in the world.

Nuclear standards sought

An attempt was made in Geneva last month to unify the standard practice of countries which are developing peaceful uses of nuclear power. Experts from some 30 countries held the first meeting of a new committee on nuclear energy of the International Organization for Standardization. Object will be to recommend standard practices for nuclear plant and equipment which should be followed throughout the world in the interests of safe and efficient operation and improved trade. The British delegation of nine was led by Mr H. A. R. Binney, director of the British Standards Institution, and included representatives from the UKAEA, the CEA and three of the industrial groups of NETAC.

SOVIET UNION

Hardening metals by radiation

Investigations which may result in the development of exceptionally durable high-speed cutting tools have been described to a *Tass* correspondent by Dr Alexei Malkin, director of the USSR Tool Research Institute.

According to Malkin, metals and alloys acquire additional strength when subjected to a certain intensity of irradiation. In some instances the strength and hardness of the metal are claimed to increase several times over. This is believed to be due to changes in the structure of the metal.

Dr Malkin told the correspondent that detailed work on this problem has begun at the Institute's new laboratory for the study of metals by radiological methods.

Project 1 detailed

More details of Russia's atomic programme came to light at the recent Belgrade meeting of the World Power Conference. As has already been reported (*Worldview*, July) the Soviet has at least two types of full-scale power stations in construction—Project 1 and Project 2. Project 1 is a two-reactor pressurized-water plant for 390 MWe and the details now released show this to be very similar to the United States Shippingport PWR, but very much larger.

Each reactor will supply three 70 MW turbines (Shippingport has one 60 MW set which will later be stepped up to 100 MW) giving a gross installed capacity of 420 MW but this is apparently only the first phase of what is presumably a very large station indeed. Each reactor will have a thermal rating of 760 MWt and the water will be circulated in six parallel loops. Pressure in the shell will be 1470 psi and the water will be heated from 480 to 530 deg F, the flow rate through the core being 120,000 gpm. Inlet to the shell is above core level and the feed water will drop through a downcomer section between core and wall before entering the core and rising up through it to the offtakes.

The shell will be 12·5ft dia. and nearly 40ft high, 7 in. thick and will be in high yield point steel clad internally with stainless. The top closure will include the control rod entries as at Shippingport.

Fuel will amount initially to about 17 tons of natural uranium metal and about 23 tons of uranium oxide enriched to 1·5 pct. It will be cased in zirconium tubes a number of which will be held inside hexagonal zirconium casings through which the water will rise. There will be 349 of these casings, 10·5ft high and arranged on a triangular lattice.

Steam will be generated at 230 tons an hour, 470 psi dry sat. in shell and tube exchangers. Canned motor pumps have been developed for this job delivering 23,000 gpm against 70 psi. These are single-stage, vertical shaft units. Control of the reactor will be fully automatic, based on a constant primary coolant temperature. Overall station efficiency was claimed to be 27·5 pct and station consumption to amount to about 7½ pct of the gross output.

The other large station, Project 2, is apparently a development of the Russian 5 MW station and will be graphite-moderated, water cooled. Overall, the Russians are planning to have an installed nuclear output of between 2000 and 2500 MWe by 1960.

Smaller power projects in hand include: a 70 MWe boiling water reactor for resonance stability work and investigations on prolonged operation of turbines on radioactive steam; a 30 MWt two-zone aqueous homogeneous reactor for power feasibility studies; a 150 MWe sodium-graphite reactor—this will use an intermediate NaK loop; a 50 MWe fast breeder working on Pu-239/U-238—this will have mechanical pumps in both primary Na and secondary NaK circuits.

UNITED STATES

UN recommends $M6 for IAEA

A commission of 18 members meeting in New York has produced a 55-page report and recommendation for the International Atomic Energy Agency. This is for consideration by the general conference, meeting in Vienna on October 1. The commission proposes a $M6 budget and a staff of 369, headed by a director-general, and including 15 divisional and other directors. They would administer economic and technical assistance, research, isotope and reactor matters, waste disposal, health safeguards and the exchange and training of scientists and technicians. Priority attention is recommended to health hazards and to the increased use of radioisotopes as a research tool especially in less developed countries. 'The possibility of contamination of the sea, air and waterways illustrates the need for action by an international body,' says the report. It also calls for the creation of a reliable system of safeguards against the diversion of

fissionable materials to military use. Initial dependence on the more advanced member countries for trained manpower and training facilities is recognized, and also dependence on these countries for supply of fissionable materials and fuel fabrication facilities.

Member countries of the commission include the UK, USA, the Soviet Union, Canada and France. President is Sr Bernardes of Brazil, vice-president P. Winkler of Czechoslovakia and executive secretary Dr P. Jolles of Switzerland. A Bill passed by voice vote in the Senate last month placed tight restriction on President Eisenhower's authority to hand over nuclear fuels to the International Atomic Energy Agency. In future each transfer would require specific approval by Congress. Earlier the restriction was rejected by the House of Representatives on a 298 to 99 vote. The measure was written into a Bill, passed by the House, providing for the appointment of US representatives in the Agency and detailing other aspects of American participation. Two exceptions in the Senate's restriction are: no Congressional action will be needed for the transfer already promised of 5000 Kg of U-235; and the US would be authorized to give up to $10,000 worth of materials to one country or $5,000 worth to a group of countries in one year for research programmes.

HRE-2 critical at end of year

Construction of the Homogeneous Reactor Experiment no 2 at Oak Ridge is complete and re-operational testing is now in progress. Due to go critical at the end of this year, it is built in the same building as HRE-1 which went critical in 1951 and was dismantled in 1954 after two year's successful operation. HRE-2, previously known as the Homogeneous Reactor Test (HRT), is designed for a feasibility study of homogeneous aqueous reactors for power, and is virtually a full-scale prototype power reactor. Fuelled by a solution of uranyl sulphate, highly enriched in U-235, in heavy water, it is a two-zone, forced circulation type operating on the thorium/U-233 breeding cycle. Core design is mechanically simple, being a sphere of 32in. inner diameter made of $\frac{5}{16}$in. Zircaloy-2. Pressure vessel is in stainless steel, 4·4 in. thick.

No Calders wanted

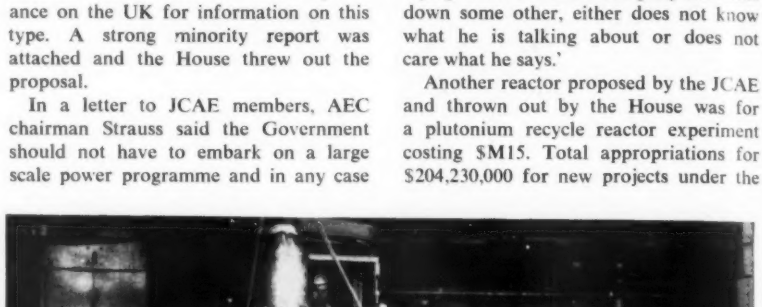
An attempt by the Joint Committee on Atomic Energy to have the Atomic Energy Commission sponsor a full scale natural uranium gas-cooled reactor was squashed last month when the House of Representatives voted against a JCAE majority report. This proposed to allocate the AEC $M40 to build the smallest practicable Calder-type reactor designed for higher temperatures, and suggested that overall control of the project should be in the hands of Admiral Rickover. The idea, according to Representative Melvin Price (Dem. Ill.), a supporter, was to enable the US to compete more effectively with the British for overseas markets and to remove their dependance on the UK for information on this type. A strong minority report was attached and the House threw out the proposal.

In a letter to JCAE members, AEC chairman Strauss said the Government should not have to embark on a large scale power programme and in any case the technical choice of reactors was within the special competence of the Commission. Furthermore, Mr Strauss said this reactor could only be little better, if any, than Calder Hall 'which we feel is already obsolete.' He added that the JCAE's move showed 'a strong bias in favour of public power, government ownership and socialism.'

This defeat for the JCAE is another move in the long political struggle between the Democrat-dominated Committee and the AEC on the issue of Government participation in power projects and recalls the ill fated Gore Bill which failed to get House approval last summer. This would have given the AEC power—which it does not want—to complete large prototype power plants instead of leaving this to industry.

Speaking in the senate later, JCAE chairman Clinton P. Anderson (Dem. NM) said he had been accused of trying to help two private organizations (Westinghouse and General Electric). He denied this and said they had proposed the reactor without regard to who might do the job . . . 'anyone who says we are trying to favour some company and hold down some other, either does not know what he is talking about or does not care what he says.'

Another reactor proposed by the JCAE and thrown out by the House was for a plutonium recycle reactor experiment costing $M15. Total appropriations for $204,230,000 for new projects under the Commission's regular plant and facility authorization were voted by the House.



Now installed at ORNL, the HRE-2 core has an outer thermal shield fitted with helical cooling coils, surrounding the main pressure vessel. Inside this is the Zircaloy fission vessel

Meanwhile a private company is working on a gas-cooled reactor. In its annual report for the year ended April 30, ACF Industries Inc discloses that it has been doing preliminary design studies on a natural uranium reactor 'to meet the needs of one section of the foreign market.' ACF claim that, measured by kilowatt output it is the nation's leading manufacturer of commercial test and research reactors.

Investment doubled in five years

On June 30, the nations investment in atomic energy facilities was about $M7000—a doubling in five years—according to the AEC's 22nd semi-annual report published on July 31 in Washing-

ton. During the six-month review period eleven US-built reactors went critical: two of these are power plants—the Sodium Reactor Experiment and the Army Package Power Reactor. Of the others, six were for research and training (one is the AMF pool at Amsterdam) and three were criticality experiments. In the same period construction began, major components were ordered or construction permits were issued for 22 reactors. These include one AEC power experiment and 11 military power reactors—presumably for submarine and other ships. Reactors planned at the end of the period were 35; seven of which are export. Six of the 35 planned are full-scale civilian power reactors, and one of these is for export.

The United States has reached the position where her supplies of uranium from domestic and contract sources is foreseen as being enough for all her commitments for the next ten years—military, civil and international. Predicted production of uranium oxide is 10,800 tons by the end of this year: 14,000 tons by the end of 1958.

Progress on the plutonium problem is reported and four Pu fuel elements together with three Pu shim fuel rods were put into the Materials Testing Reactor at Idaho Falls. Object of this is to produce gram amounts of high Pu isotopes together with transplutonic elements and also to study irradiation damage. Shim elements will have 2 years in MTR, fuel elements 150 days.

Two new aqueous processing systems are being investigated. *Darex*, under investigation at ORNL and Idaho involves treating stainless-steel-bearing fuels with nitric/hydrochloric acid mixtures. The other is *Zircex*—also an ORNL project. This involves anhydrous hydrochlorination of zirconium-bearing fuels under conditions such that the zirconium can be separated as a volatile product. In both processes the uranium stream can be converted to an aqueous uranyl nitrate solution and fed to a conventional liquid/liquid extraction system. This work is aimed at reducing processing costs before private industry enters the field.

Contribution of isotopes to the national economy is officially estimated to amount to the staggering figure of about $M400 a year. Over 4000 organizations are now licensed to use isotopes and the number is growing rapidly. A curious item is the disclosure that a small shipment of carbon-14 for the Moscow Biochemical Institute was recently approved by the AEC. Demand for certain isotopes —notably tritium and krypton-85—is now said to exceed supply. Cobalt-60 is also in heavy demand and the AEC are making arrangements to increase production.

WORLDBRIEFS

Agreement was signed on August 1 in Turin between Westinghouse Electric International president W. E. Knox and Fiat president Vittorio Valletta under which Fiat will build Westinghouse pressurized-water and other reactors. The two companies already have a series of licence agreements in other fields. Edisonvolta, Italy's largest electricity undertaking, ordered a 134 MW pressurized water reactor from Westinghouse last December.

Yankee Atomic Electric to be given construction permit by AEC for 134MW nuclear power plant at Rowe, Mass.

US Navy have ordered construction of 80,000 ton atomic-powered carrier. Overall flight-deck to be 1088 ft; cost about £M107; scheduled for completion 1961.

Installation of million kW atomic power in India by 1965 is technically feasible, says Dr H. J. Bhabha, Indian AEC Chairman. Difficulties are technical and economic.

Twenty students have been enrolled at Nuclear Energy Training Centre at Baghdad. Director of Centre is W. J. Whitehouse, ex-Harwell; British equipment was installed earlier this year. Australia will contribute source materials and research results to IAEA.

Permits for the construction of seventeen low-power reactors—1/10 to 5 watts heat output—have been granted to Aerojet-General Nucleonics of San Ramon, California.

Dutch government is to give financial support to the Netherlands Reactor Centre's 3-year plan, which includes study of nuclear ships.

Re-elected Sir Luke Fawcett and Sir Ivan Stedeford as part-time members of the UKAEA. Sir Luke to Dec 31, 57, Sir Ivan to July 31, 59.

Draft of new code to protect factory workers from radiation hazards was published on July 24 by Ministry of Labour.

Heavy water production from Farbwerke Hoechst's new plant near Frankfurt will amount to about 10 tons a year. Process is distillation at minus 250 deg. C.

Tokyo was objective of mission from English Electric/Babcock & Wilcox/Taylor Woodrow atomic group. It included Babcock's W. R. Wootton and A. Reishel and EE's J. F. Herbert

Prime Minister visited both Harwell and the Weapons Establishment at Aldermaston last month. Mr Macmillan told Aldermaston workers—your skill will be equally needed in the task of peaceful development

Burma Atomic Energy Centre has had a two-year development plan prepared for it by Dr R. F. Humphreys of Armour Research Foundation, Chicago. It will concentrate on setting up laboratory facilities and training scientists.

Power was produced for the first time by the Sodium Reactor Experiment, Santa Susana, California on July 12. Output was about 1MW and this will be raised to 6·5 MW by the year's end.

Israel's benefit from atomic energy cannot be very great before about 1965 according to a report issued by the National Planning Association in the United States last month. In the long run nuclear power might open up new sources of irrigation and help develop the mineral resources of the Negev.

Brazil is to get 550 kg of contained U-235 from the USAEC for a power reactor and a materials testing reactor. Agreement is for 20 years.

Critical, at Saclay July 9, the French EL3 heavy-water moderated high-flux test reactor. Message from Pierre Guillaumat, Commissariat à l'Energie Atomique Administrator General to USAEC thanked them for 2,500 kg of U-235.

OEEC has been presented with an extensive collection of documents, prepared by the AEC, containing all declassified US information on nuclear energy not published in scientific and technical journals.

Spain has signed a cooperative agreement with USA under which 500 kg of U-235 will be provided over a 10-year period.

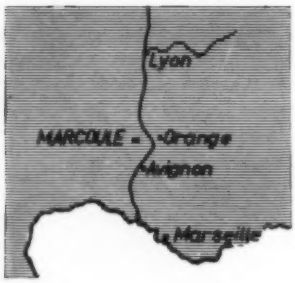
Peruvian atomic chief General Jorge Sarmiento was in Britain for three weeks recently visiting Calder, Harwell, several universities and industrial nuclear establishments.

Hungary's small experimental reactor near Budapest is expected to start operating in 1958-9. To be used as a training ground for engineers for the projected power station.

UNESCO conference on radioisotopes in scientific research will be held in Paris from September 9 to 20, with Sir John Cockcroft as president.

Electric Boat Division of General Dynamics Corp is to build smallest yet atom submarine; cost—about $M50.

Licence for the manufacture of Westinghouse nuclear equipment has been awarded to two Belgian firms, Ateliers des Constructions Electrique de Charleroi and Cockerill-Ougrée.



The Commissariat à l'Energie Atomique's industrial centre in the South of France includes one of the world's first nuclear power stations—G1. Soon two much more powerful reactors will be in operation, producing plutonium and electricity

Report fro Ma

by The Editor, Nuclear Power

MARCOULE LIES on a south-facing hillside overlooking the right bank of the Rhône about 15 miles upstream from Avignon and is sheltered to the north by *La Dent de Marcoule*, a rocky bluff rising to about 700ft. The site was chosen because: it is remote from large centres of population, yet reasonably accessible; the Rhône provides ample cooling water and a drain for low-activity effluent; all buildings are well above flood level, yet not so high as to make pumping power prohibitive; it is nowhere near an airport, so the high stacks are not an embarrassment.

Eighteen months to build G1

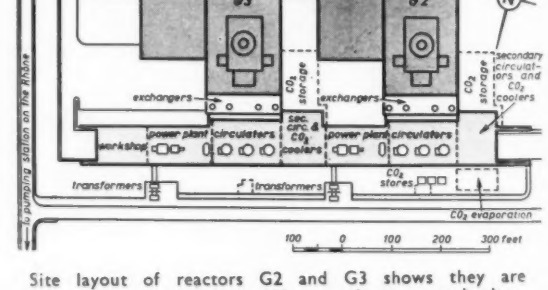
The work is now nearing completion and next year will see it through. There will then be three natural-uranium, gas-cooled reactors and a plutonium separation plant with a graphite machining plant as an ancillary service. Construction of Marcoule's first reactor, G1, started in September 1954 and it went critical on January 7, 1956, after the very short construction period of only 15 months. Incidentally it diverged with a charge of only about 20 tonnes of natural uranium which underlines the very high nuclear qualities of French reactor materials.

The core is a horizontal cylinder 29ft long and 31ft dia, including 2ft of reflector all round. It is not strictly a single cylinder but two, end-to-end, separated by a 3in. gap through which the coolant—filtered air—enters and flows outwards through the two halves. Coolant channels number 1337 and at 2¾in. dia (70 mm) contain the 2½in. o.d. (62 mm) fuel elements. These cartridges are 12ft 6in. long and one lies in each half of the core channels. The actual uranium slugs are about 1in. (26 mm) dia and about 4in. (100 mm) long. They are canned in an extruded magnesium can with eight longitudinal straight fins running the whole length. The total fuel charge is about 100 tonnes for a thermal output of 40MW.

Outdoor turbine plant

Cooling air is drawn in through a 82ft high stack and filtered to remove 97 pct of atmospheric dust. Four 2600kW motor-driven blowers supply the air to the centre inlet of the core but it is cooled to 18°C before delivery. On leaving the two ends of the core the flows rejoin and are taken by an underground duct to a heat exchange section in the open air where saturated steam is raised for use in a vertical shaft turbine with an MCR of 5·75MW. The air is finally discharged through a high stack with a deflector on the top to ensure it is fully dispersed. The heat recovery plant of G1 was not envisaged originally but was included during construction at the request of Electricité de France who wanted to obtain operating experience with a nuclear power plant; the system was fully described in NUCLEAR POWER Vol 1 pp 211 ff (Sept and Oct 1956).

Returning to the reactor, the control rods are mounted vertically and penetrate between the horizontal fuel channels. Charging is not done under load but the horizontal layout permits charging and discharging at opposite ends of the core. A new cartridge entering the first half of the core is used to push out a spent one from the second half into a lift in a shielded space. Here it is placed in a container and lowered to an underground storage space to await transport after cooling to the separation plant. This method ensures a uniform burnup, for slugs undergo a period of irradiation in each half of the core.



Site layout of reactors G2 and G3 shows they are separate production units. Heat exchangers, turboalternators and turbocirculators are all outdoor

G1 first delivered power in September 1956. Next month however there occurred a fuel element burst and the cladding caught fire. About three-quarters of one element melted and particles of uranium oxide became embedded in the graphite. A special tool was devised for clearing the hole and the pile was re-started in January 1957. Since then, there has been a further outage while an additional heat exchanger section was fitted. This was completed in July and it is now hoped to work the plant up to rated output. G1's first consignment of plutonium is expected to be ready for the separation plant by the end of the year.

Marcoule

Air for G1 reactor—housed in the completed building—is taken through the nearest stack. After passing through the reactor and heat exchanger it is discharged through the far stack

Increasing plutonium production

When approval was given for G1's construction, the building of a more powerful reactor, G2, was included, G1 and G2 to have a combined annual output of about 50kg of plutonium. In 1955 however, it was decided to double up on this and a twin for G2, G3, was approved. G2 is now in an advanced stage of construction and is due critical next spring with G3 following about six months behind.

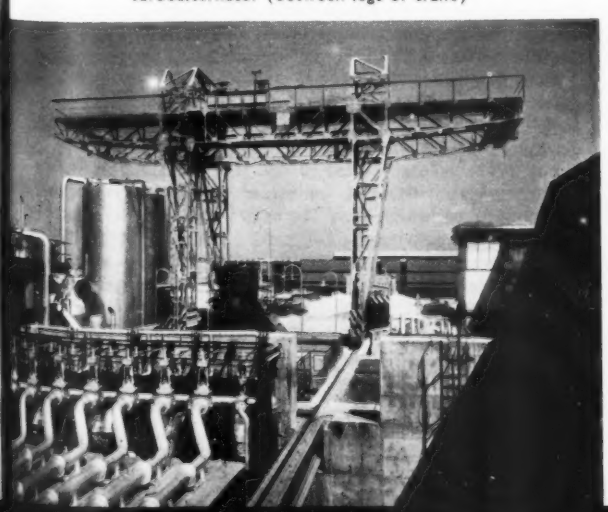
Broadly similar in conception to G1, G2 and G3 differ greatly in detail. The horizontal channel layout is retained but the coolant is now pressurized carbon dioxide and it is no longer supplied to the centre of the pile, but enters and leaves from the same end. Turbine plants are incorporated from the start and each reactor will produce 40MWe net, the main circulators being turbo-driven and thus not encroaching on this output. The gross output is therefore almost exactly the same as Calder Hall A, and the two plants strictly comparable. G1 and G2 although identical are completely self-contained production units. They will have two features that will make them unique for a time: prestressed concrete pressure vessels and on-load fuel charging.

Prestressed shell

The reactor core is a horizontal octagonal cylinder about 34ft long by 32ft dia including 3ft reflector all round. Graphite blocks, made by the Péchiney company at their factory at Chedde, are machined in a special shop at Marcoule. They are 200 mm square in section, about 4ft long and each standard block has a half-round groove in two opposite sides which, when the blocks are fitted together, form the 70 mm dia cooling channels. The size of these blocks determine the lattice pitch which is thus also 200 mm (about $7\frac{7}{8}$in.). There are 1200 channels. The fuel is natural uranium of the same diameter as the G1 slugs (26 mm), but in G2/3 they are 30 cm long. These are sheathed in finned magnesium cans which lie in the horizontal channels. Total fuel charge is about 100 tonnes.

The whole core is mounted within a closed thermal shield forming part of the gas distribution system. This in turn is supported on the floor of the massive pressure vessel which is designed to give adequate support against core flexure. The form of this can be seen from the illustrations. It is cylindrical with re-entrant hemispherical ends, the whole structure merging below into an immense concrete block. Prestressing is by the Freysinnet system with circumferential and longitudinal cables, postensioned. The shell is 46ft i.d., about 10ft thick and 110ft long: it is lined throughout with steel sheet of about 1 mm thickness but it should be emphasized that this contributes no strength to the shell and only provides a leak-tight seal. The pressure vessels on G1 and G2, which of course are also biological shields will be tested to 430 psia and will normally run with a gas pressure of about 215 psia.

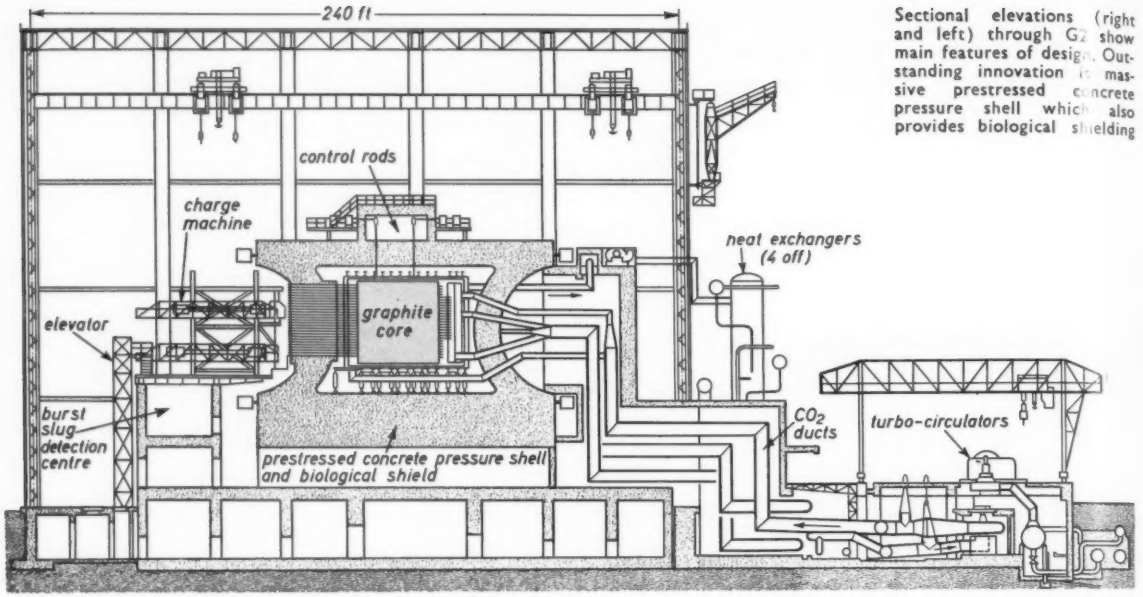
G1 heat recovery plant is quite separate from the reactor building. Three boilers in cascade fed from a single heat exchanger (foreground) supply a 5·75MW vertical shaft turboalternator (between legs of crane)



Zoned gas distribution

About 80 tons of CO_2 will be circulated through each reactor by a pair of 3850kW geared vertical shaft turboblowers, a smaller 2350kW set being held for standby duty. There is quite a considerable space between the concrete liner and the thermal shield containing the core, and the main pressure shell is cooled by carbon dioxide supplied by an independent motor-driven secondary gas circulation system. The shield cooling gas enters at 77°F, leaves at 80°F.

The gas distribution system is complicated. The reactor core is divided into inner and outer annular zones but the exit zones do not correspond directly with the entry zones. Gas is led from the circulators in circular ducts to one face of the reactor and from thence to the two inlet zones. Outlet ducts lead back through the same face to



Sectional elevations (right and left) through G2 show main features of design. Outstanding innovation is massive prestressed concrete pressure shell which also provides biological shielding

the four heat exchanger towers mounted outside the reactor buildings. Temperatures and flows in the core are as follows, for a heat output of 200MW:

	Temp °C	flow lb/s
Inner zone, entry	80	1160
Inner zone, exit	305	1810
Outer zone, entry	150	1030
Outer zone, exit	354	390

Total flow 4390 lb/s

Carbon dioxide is stored in liquid form at −20°C and 90 tons are held in 3 vessels at 140 psi. There are two evaporation sets for each reactor with a capacity of 2 tons an hour. Fully charged, a reactor holds about 80 tons of gas and for make up about 11 tons of evaporated gas is held in six vessels. In the working circuit, a continuous clean up system is used and about 2 lb/s are bypassed, filtered on paper, passed over an activated charcoal bed to remove any oil or moisture and finally dried on alumina before returning to the circuit.

Triple-pressure cycle

The four boilers or heat exchangers are connected to the reactor in parallel and are steel shells 106ft high, and 11ft 9in. dia. These were delivered in one piece by road transport from near Paris a distance of about 750 miles. Inside, the exchangers have economizer, evaporator (h.p. and i.p.) and superheater (h.p. and i.p.) sections, the gas flowing counter to the water in three vertical passes. Water and steam tubes are vertical and have extended surfaces. Steam is generated at three pressures as follows:

Low pressure—7 psia, 178°F by flashing water from the economizer outlet in a drum.

Intermediate pressure—31 psia, 340°F, by superheating steam from the l.p. drum.

High pressure—150 psia, 630°F from the h.p. superheater.

Steam is taken to the turboalternator which has three admissions. This is a normal horizontal shaft machine with an MCR of 40MW and directly coupled to a 45MVA, 10·5kV alternator generating at 50 c/s, 3000 rpm.

WHAT IS MARCOULE FOR ?

The keystone of France's first atomic five-year plan, started in 1952, was plutonium production in large gas-cooled, graphite moderated natural uranium converter reactors using fuel produced from her considerable reserves of uranium ores. In metropolitan France alone, these are estimated to amount to between 50,000 and 100,000 tons of metal and her overseas territories—particularly Madagascar—are believed to be very rich in ores.

Building plants to mine and process these ores was a large part of the first five-year plan but Marcoule represents the ultimate—the factory where the precious plutonium will be produced at the rate of about 100 kilogrammes, about 2 cwt, a year. The plutonium is bred from uranium in the reactors and then separated chemically.

The power unit is in the open air and the output is stepped up to 62kV for distribution to the grid. A secondary transformer steps down to 5·5kV for station use.

Steam dumping

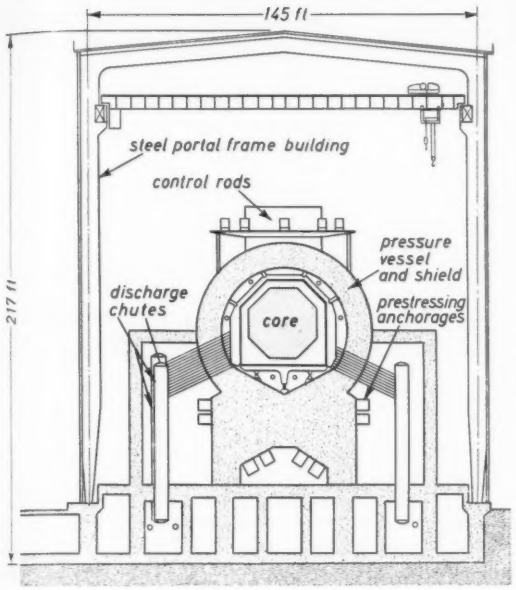
The flow rate to the condenser is about 200 tons an hour which requires approximately 11 tons a minute of circulating water.

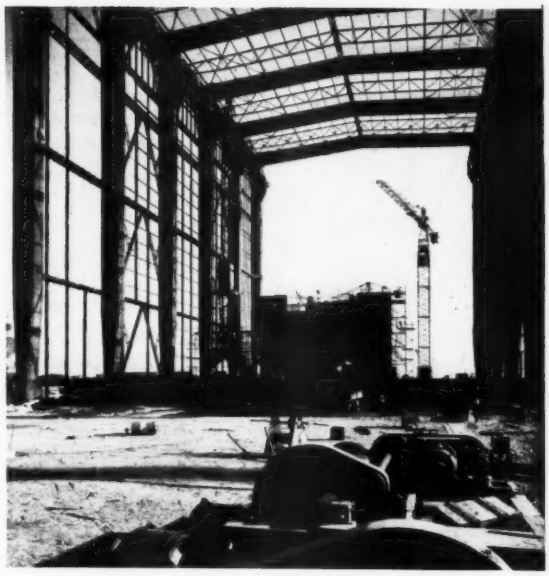
For start up and reduced power operations a dump condenser capable of handling the whole output is fitted and the turbine condenser can also be used for dumping, desuperheaters being fitted in each case. A vacuum of about 27½in. is maintained in the dump condenser by an extraction pump. Details of steam flows are as follows (kilopounds an hour):

turboalternator: h.p. 378 i.p. 52 l.p. 25

turbocirculator: i.p. 98 TOTAL STEAM 553 klb/h

The reactor halls for G2 and G3 are vastly impressive, simply constructed in box-section steel portal frames clad largely with corrugated panels and glazing. They are 240ft long and 217 ft high and the pair are ranged side by side with low ancillary buildings between.





Shot of early stage in G2 construction shows reactor foundations—the reactor pressure shell is now complete

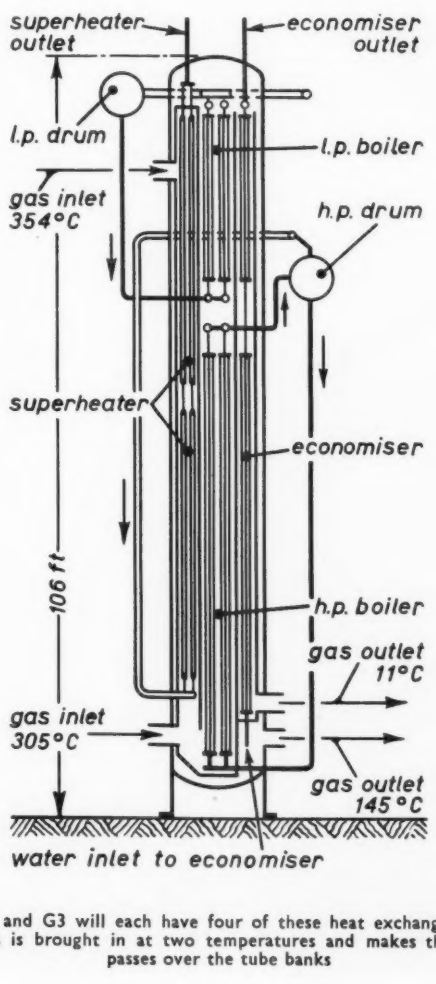
WHY PLUTONIUM ?

In Britain we produce it for weapons but so far France has not said she will make an atomic bomb. On the other hand she has not definitely renounced the possibility and it is believed that Marcoule's plutonium—like Calder Hall's—will be of the very pure weapons grade. Thus France will have a stockpile should she need it. The French believe however that the key to economic atomic energy lies in using plutonium in advanced nuclear reactors and although neither they nor anyone else has found out exactly how to do this they fully intend to make it work. This will form an important part of her second five-year plan, just commenced. Another fuel is possible for advanced reactors—uranium 235. This can be obtained at present only from America, but France is now considering building a plant for this although the product would be very expensive.

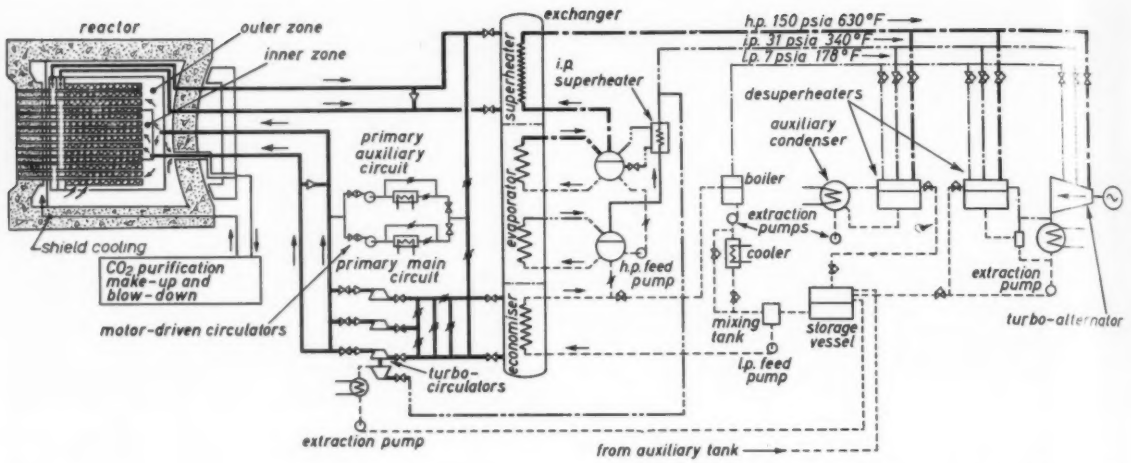
Spent elements discharged by gravity

Charging of G1 and G2 will be done on load without depressurizing. Fresh elements, inside a purged flask are brought up on a horizontal charging machine to the charge face which is provided with standpipes through the concrete. As the new element is pushed into one end of the fuel channel in the core, a spent one is ejected from the other end into one of a series of downward sloping chutes leading out through the thermal shield and pressure shell at the gas entry end of the core. The chutes connect outside the pressure shell, but still behind heavy shielding, to vertical ducts containing a spiral slide which convey the hot slug to the basement at a controlled speed.

When NUCLEAR POWER visited Marcoule in July, both G2 and G3 buildings were virtually complete. The cylindrical portion of G2's pressure vessel had been poured and formwork was being erected for the dished ends. No core laying had been started. An interesting erection feature was the use of a tall 'goal-post' gin pole for raising the heat exchanger shells on to their bases. This was done with the shells empty, the tubing and steam drums being installed after erection.

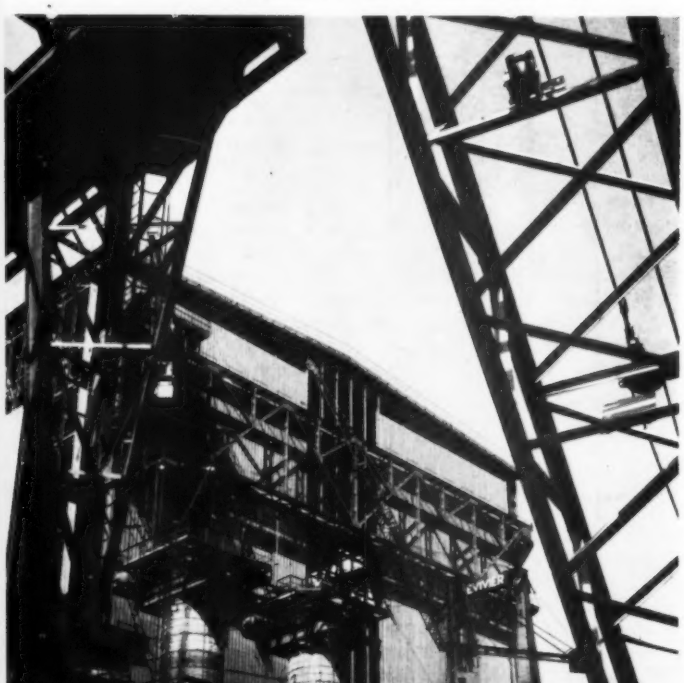


G2 and G3 will each have four of these heat exchangers. Gas is brought in at two temperatures and makes three passes over the tube banks



Simplified flow sheet for G2/G3 shows how steam is raised at three pressures. Gas circulation is by turbo-blowers run off the i.p. steam range

Two of G2's heat exchangers are already erected—two more will follow. Over 100ft high, the shells were brought in one piece 750 miles by road. Gantry crane in foreground is permanent and serves power plant



The turbines and gas circulators are all in the open air with the units for both reactors served by a single travelling gantry crane.

TBP solvent extraction

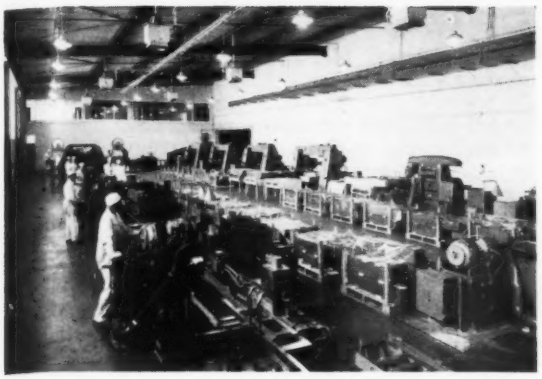
Nearing completion on the higher ground towards the north of the site, is the striking plutonium separation plant. Basically a rectangular building almost entirely in massive shielding concrete, its unusual appearance is due to the viridian glass curtain walling panels that enclose the exterior working areas round the active cells.

The process used for separation is very similar to those used in the USA and in England but was devised completely independently. Indeed work started on the plant 3 months before the Geneva conference (Aug 1955) and the French engineers claim that although much information was disclosed at Geneva they saw no reason for altering the system they had chosen. This is straightforward dissolving in acid, and solvent extraction with tributylphosphate in kerosene, with some new twists.

MARCOULE AND CALDER . . . HOW THEY COMPARE

Reactors G2 and G3 at Marcoule correspond very closely in total output with Calder Hall A station

	MARCOULE G2 reactor	CALDER HALL one reactor
Turbine capacity, MW	40+7.7=47.7	2 × 23=46
Gas inlet temp. °F	176, 302 (2 zone)	284
Gas outlet temp. °F	580, 670 (2 zone)	637
Gas pressure psig	200	100
Steam pressures psia	150, 31, 7	210, 63
Core diameter feet	26	31
Core length feet	28	21
Lattice pitch inches	7.86	8.00
No of channels	1200	1696
Channel dia. inches	2.75	4.16, 3.95, 3.61
Total uranium tonnes	100	130



Moderator graphite blocks for the Marcoule and other French reactors are machined in this one shop. Nearest machine shows duct collecting hood and extract pipe

A hundred kg of Pu a year

On arriving at the Pu plant in a heavily shielded container on a special vehicle, the slugs are raised to the upper storey to begin their treatment. At this stage the rods have been decanned but they are first given an acid treatment to remove traces of Mg left from the can. They are then dissolved completely in nitric acid and passed to the extraction columns which produce three aqueous streams: fission products, depleted uranium and plutonium. The plutonium stream after purification in ion exchange columns is precipitated as an oxalate.

When the plant is commissioned, later this year, all the highly active cells will have been sealed off with concrete and further access will be impossible. As in British practice, all vessels and pipes are in welded stainless steel with no valves or pumps in the highly active parts. Alpha protection in the access areas is given by an air conditioning system using the principle of inward leaks throughout. Exhaust air is discharged through a 250ft-high stack. The plant is designed to produce at least 100 kg of plutonium a year and will be manned 24 hours a day by a staff of about 350 men.

Graphite on the spot

All the moderator blocks for G1, G2 and G3 and the reflector blocks for Saclay's new EL3 heavy-water research reactor were machined in a special *atelier* set up at Marcoule. Rough billets arrive from the Péchiney graphite factory in cardboard boxes and kept in a store adjacent to the machine room. The blocks are first lifted onto a roller conveyor by air-hoist and then passed to a pair of band-saws that square up the rough ends. The next step is milling the edges, two at a time, separate machines carrying out the two operations required. Transfer between machines is on the roller conveyor and the workpieces are pneumatically clamped into fixtures for machining. The two ends are then milled on separate machines and the blocks are now exactly to size. The milling cutters have usually six cutting edges formed by disk-shaped cutters bolted to rotating chucks. These machines are by *Entreprises Schneider*. As already mentioned, G2 and G3 blocks are 20 by 20 cm in section and about 4ft long and have a groove of semicircular section cut along two opposite edges so that when a pair of blocks are butted the fuel rod channel is formed between them. These grooves are cut by similar milling cutters. Each block travels with its own work sheet which states what operations are required on it, for of course some blocks are of special shape to accommodate control rods, etc. At the end of the line the block with its work sheet is wrapped in polythene sheeting, cartoned and stored. A big vertical spindle milling machine with turntable was used for making reflector blocks for EL3.

Every machine has a most efficient dust extract system and although the floor was a trifle slippery there was no sign of dust in the atmosphere. The plant appeared to operate with a shift of about a dozen men who wear simple white overalls, caps and gloves. Throughput of graphite in this small factory covering an area, one estimates, of about 35 by 75 ft is said to be about 3000 tons of machined blocks a year.

France's power plans

While Marcoule's reactors will provide the first atomic power in France, her first commercial power station will be Electricité de France's EDF1 plant at Avoine on the Loire, near Chinon. Due for commissioning in 1959 with an output of 60MW from a single reactor it is also a gas-cooled natural graphite plant. The horizontal fuel channel layout has however been abandoned in favour of the vertical and the core will be contained in a steel pressure shell designed for 360 psi gas pressure. A model of the EDF1 is on view at the *Het Atoom* exhibition in Amsterdam and it shows a core vessel and heat exchangers all within a spherical containment shell. Under France's second five-year atomic plan, further EDF stations of increasing output are scheduled to follow at 18-month intervals.

They built Marcoule

Principal contractors at Marcoule include

REACTOR G1
SOCIETE ALSACIENNE DE CONSTRUCTIONS MECANIQUES: coordination and construction
SOCIETE ALSTHOM: electricity generation plant
SOCIETE DES FORGES ET ATELIERS DU CREUSOT: construction
SOCIETE RATEAU: turbine plant

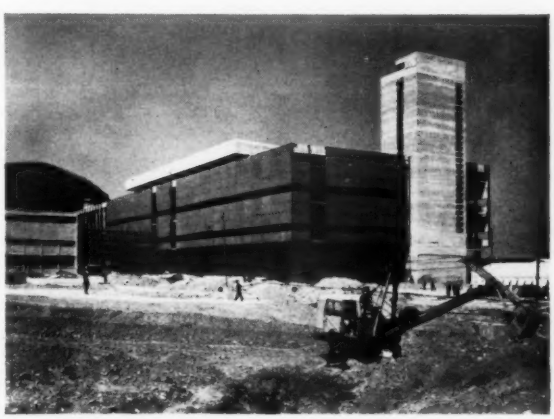
REACTORS G2 and G3
The above companies plus
LE GROUPE LOIRE-PENHOET

PLUTONIUM SEPARATION PLANT
SOCIETE SAINT-GOBAIN

GRAPHITE PLANT
COMPAGNIE INDUSTRIELLE DE TRAVAUX ENTREPRISES SCHNEIDER

The head of the Marcoule plant is M. Pierre Taranger, Industrial Director of the Commissariat à l'Energie Atomique.

Most striking building at Marcoule is the 100 kg-a-year-plus plutonium extraction plant. Operating areas are behind glass curtain walling surrounding the heavy concrete active cells



The most promising way of raising temperatures in Calder-type reactors is by using better canning materials for fuel elements. Here is what is known about one of them —

BERYLLIUM

G. L. MILLER PhD, ARIC, MIChemE, MinstMM
Research Manager, Murex Ltd

ALTHOUGH THE PRODUCTION of beryllium has been established for about twenty-five years the usage of unalloyed metal has until recently been limited to very small quantities for such specialized uses as x-ray windows. By far the major part of the output of the beryllium industry has been in the form of beryllium copper.

Beryllium oxide is used in fair quantities. It is a very good refractory material with a very high melting point, excellent resistance to thermal shock, high seat conductivity and absence of contamination to the melt.

The beryllium industry is an expanding one as is shown by the fact that usage of beryl ore in the USA increased from 200 short tons in 1937 to nearly 3,500 tons in 1952. In the last few years beryllium has attracted considerable attention from the designers of nuclear energy equipment because of its low neutron-absorption cross-section coupled with its ability to moderate the velocity of neutrons. A more recent development is the suggestion that beryllium could be used as a structural material for aircraft.

Beryllium industries were established almost simultaneously in America and Germany but as production has been discontinued in Germany since the war the main industry has been confined largely to the USA. Production in the United Kingdom is confined to the UK Atomic Energy Authority's plant at Milford Haven operated by Murex Ltd, and the pilot plant operated by Imperial Smelting Co at Avonmouth.

The future of beryllium can be gauged from the fact that the United States Government has just contracted for one million pounds of metal.

Occurrence of ore

Beryllium is widespread in nature and occurs in several forms but the only commercial source of the metal is beryl, a beryllium aluminium silicate. This mineral has a theoretical beryllium content of 5 per cent but the commercial form contains between 3·5 and 4·2 per cent. The mineral does not occur as concentrated deposits and is generally obtained as a by-product from the mining of feldspar, lithium or mica. As the density of the beryl is very similar to that of quartz, feldspar and common gangue materials, it cannot be recovered by hand picking which is not only laborious and therefore expensive, but inefficient, recovering only about one-third of the beryl. Investigations are proceeding in the USA to develop methods capable of up-grading fine-grained beryl but so far no success has been obtained. It is probable that the failure to produce results is linked with a fairly easy supply of beryl from other sources and if the position were to change a more intensive effort would yield the desired results. It also appears that efforts are being dissipated by too many projects instead of concentrating on a few. The low grade ores are enormous in extent; it is estimated that the beryl in the tin spodumene belt, North Carolina, USA, totals 823,000 tons.

The estimated total inventory of beryl ore in the United States is equivalent to 2,300,000 tons (short) of beryllium metal.[1] [3]

World reserves of beryl have been estimated at 210,000 tons (short) as 1·0 per cent ore and 3,800,000 tons (short) as 0·11 per cent quality. The major sources of the 1·0 per

Table I

PRODUCTION OF BERYL IN VARIOUS COUNTRIES—long tons

Producing Country	1948	1949	1950	1951	1952	1953	1954	1955[3]
BRITISH COMMONWEALTH								
Kenya	—	—	—	—	1	—	—	—
Northern Rhodesia	—	—	5	4	8	5	1	20
Southern Rhodesia	—	—	832	991	1,060	1,584	962	965
South West Africa	88	235	648	741	529	527	504	472
Tanganyika	2	1	—	—	—	—	—	—
Uganda	44	16	70	2	—	50	69	110
Union of South Africa	—	220	830	583	369	474	181	126
India	[a]	[a]	[a]	211	600[3]	199[3]	392[3]	845
Australia	55	35	23	112	87	125	149	230
FOREIGN COUNTRIES								
Portugal	[a]	3	51	100	92	370	329	327
Belgian Congo	—	—	—	—	—	7	44	362
Madagascar	9	27	478	522	391	461	579	316
Morocco (French)	50	157	55	83	127	32	15	2
Mozambique	16	133	260	226	205	215	500[3]	960
United States (mine shipments)	89	424	499	432	460	671	669[3]	500
Argentina	[b] 49	[b] —	[b] —	[b] —	[b] 491	[b] 610	1,280	1,488
Brazil	1,422	2,239	2,166	1,713	2,836	1,899	1,581[3]	1,820
Dutch Guiana	—	—	—	—	—	2	9	—
Total	2,000	3,700	6,100	5,720	7,500	7,399	7,264	8,543

[a] Information not available [b] Imports into the United States

cent ore are Brazil (95,000 tons), Argentine (31,000 tons), South Africa (19,000 tons), Southern Rhodesia (13,000 tons) and India (13,000 tons).[2]

The production of beryl from different countries is shown in Table I.[2]

The bulk of the beryl produced is shipped to the USA, e.g. in 1952, 1953 and 1954 the import figures were 5,978, 7,998 and 5,816 short tons respectively.[4]

American consumers have no fear of a beryl shortage and point out[5] that in 1952 the imports and domestic production totalled 6,493 tons (short) while the usage was only 3,476 tons (short). In 1953 the position was even more favourable and in the first 10 months of 1956 10,000 tons of beryl were imported and only 4-5,000 tons used. It is considered that even if the usage of beryllium expands as the result of nuclear energy applications, there is no reason to be concerned about the ore supply position, at least for some years to come.

Oxide production

There are two main industrial processes employed for treatment of the ore and they both produce the element in the form of beryllium oxide. In the first, known as the *Copaux process*, the beryl is crushed and mixed with sodium silico-fluoride and heated to about 750°C when sodium beryllium fluoride is formed which is recovered by water-leaching. The solution is treated with caustic soda to give insoluble beryllium hydroxide which is filtered, washed, dried and calcined to form beryllium oxide. In one variation of this process the sodium fluoride in the filtrate from the hydroxide precipitate is recovered by the addition of ferric sulphate. The sodium ferric fluoride precipitated is recovered by filtering, and can be used to replace sodium silico-fluoride in the initial operation.

This is the process operated by Murex Ltd at the UKAEA plant at Milford Haven: it has been described in detail.[6] The production of beryllium metal is similar to that employed by the Degussa Company which is described later but one innovation which should very considerably improve operations is the use of a removable nickel cathode, so that the deposited beryllium can be removed from the fused bath with very little adhering metal instead of the more cumbersome method used at Degussa. Operations at Milford Haven cover all stages of the process from the ore to the finished metal powder.

The second process is that devised by the Brush Beryllium Co, who discovered that when beryl ore is melted and quenched by pouring into cold water, it becomes amenable to attack by sulphuric acid producing a solution of aluminium and beryllium sulphates. The addition of ammonium sulphate forms ammonium alum which is separated by crystallization. Beryllium hydroxide is precipitated from the liquors by sodium hydroxide and converted to oxide by calcination.

Another process[7] which was operated in Germany but has been discontinued was to fuse the beryl with lime and then to treat the product with sulphuric acid to produce a solution of aluminium and beryllium sulphates from which the beryllium was recovered in a manner similar to that described above.

Conversion to metal

There are two industrial processes for the production of beryllium metal, (a) the reduction of beryllium fluoride with magnesium and (b) the electrolysis of beryllium chloride. The bulk of the beryllium metal is produced by the former process which finds particular favour in the USA. This is also the method employed on a pilot scale by the Imperial Smelting Corporation on behalf of the UK Atomic Energy Authority. The flow sheet of the process is as follows:[9,10]

1. Production of high purity ammonium beryllium fluoride salt
2. Thermal decomposition of ammonium beryllium fluoride to beryllium fluoride
3. Reduction of beryllium fluoride to beryllium metal with magnesium metal, and
4. Vacuum casting

The first step is performed by dissolving beryllium hydroxide, beryllium oxide or beryllium metal scrap in

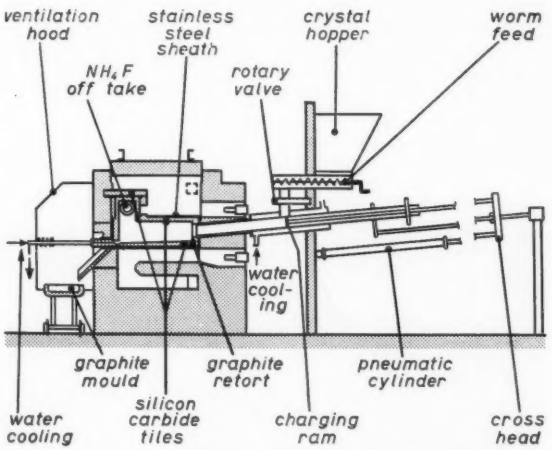


Fig 1 Metal production at an Imperial Smelting pilot plant uses reduction of beryllium fluoride with magnesium. One step in the process is the decomposition of ammonium fluoberyllate in a gas-heated furnace

ammonium bifluoride followed by separation of impurities and concentration of the solution to yield ammonium beryllium fluoride crystals. The dried crystals are decomposed at Imperial Smelting Corporation Ltd in a special furnace shown in Fig 1. The retort was maintained at 800-850°C and increased to 900°C before tapping each batch of fused beryllium fluoride. The other product of

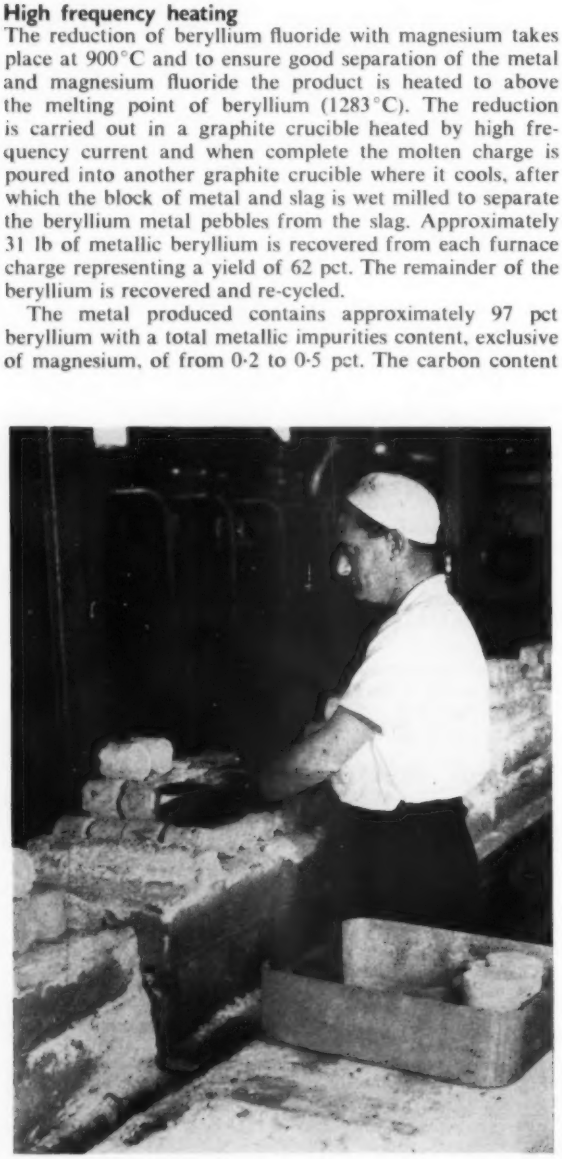
A beryllium oxide plant is operated at Milford Haven by Murex Ltd for the United Kingdom Atomic Energy Authority. Here a Sweetland filter is discharged

decomposition, ammonium fluoride, passes out as a vapour. Fused beryllium fluoride is not very hygroscopic and can be stored without special precautions.

High frequency heating

The reduction of beryllium fluoride with magnesium takes place at 900°C and to ensure good separation of the metal and magnesium fluoride the product is heated to above the melting point of beryllium (1283°C). The reduction is carried out in a graphite crucible heated by high frequency current and when complete the molten charge is poured into another graphite crucible where it cools, after which the block of metal and slag is wet milled to separate the beryllium metal pebbles from the slag. Approximately 31 lb of metallic beryllium is recovered from each furnace charge representing a yield of 62 pct. The remainder of the beryllium is recovered and re-cycled.

The metal produced contains approximately 97 pct beryllium with a total metallic impurities content, exclusive of magnesium, of from 0·2 to 0·5 pct. The carbon content



Tunnel kiln cars loaded with roasted beryl/sodium silicofluoride briquettes at the Milford Haven plant. After kilning sodium beryllium fluoride is recovered by water leaching, treated with caustic soda and calcined to give beryllium oxide

is approximately 200 p.p.m. while the BeO content is about 0·1 pct. The magnesium content as metal and fluoride may be as high as 1·5 pct.

Purification

The beryllium pebbles are purified and consolidated by vacuum melting and casting. The charge is melted in a beryllia crucible and poured into a graphite mould, the whole operation being performed *in vacuo* of about 300

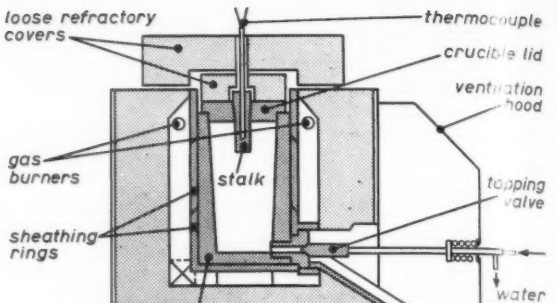


Fig 2 Further steps in process of Fig. 1, is the reduction of magnesium beryllium fluoride in a bottom-tapping crucible

microns. The vacuum treatment does not affect the impurities contained in the beryllium with the exception of the slag and magnesium content. A typical analysis of such vacuum cast ingot is shown in Table II.[9]

Table II

Analysis of Typical Vacuum Cast Ingot	
Be	99·5 pct
C	400 p.p.m.
Fe	1100 p.p.m.
Mn	70 p.p.m.
Cr	90 p.p.m.
Ni	130 p.p.m.
Mg	500 p.p.m.
Al	600 p.p.m.
B	1·2 p.p.m.
Cd	<0·5 p.p.m.
Li	<1 p.p.m.
Ag	<5 p.p.m.
Co	approx 2 p.p.m.

The reduction procedure at Imperial Smelting Corporation Ltd is somewhat different to that described above. Stoichiometric quantities of magnesium beryllium fluoride were charged into a graphite or plumbago crucible containing fused calcium chloride heated to 1000-1100°C. The crucible was heated by gas as shown in Fig 2.

Electrolytic method

Production of beryllium by electrolysis of beryllium chloride was the method operated in Germany.[7] More recently US operations have been described.[8] The process is carried out in the following steps:

1. Production of crude beryllium chloride
2. Purification of beryllium chloride
3. Electrolysis of fused bath of beryllium chloride and sodium chloride (potassium chloride is sometimes used as well)

The crude beryllium chloride is produced by chlorination of a briquetted mixture of beryllia and carbon. The product is a light powder with intense hygroscopic properties. The major impurities are iron, aluminium, and silicon present as chlorides. The iron can be separated by reducing it to ferrous chloride which is retained. The aluminium and silicon chlorides are more volatile than the beryllium chloride and can be separated by heating the condenser,

this also tends to yield a dense form of chloride which is less hygroscopic and easier to handle.

The German practice was to electrolyse a mixture of beryllium and sodium chlorides in the weight ratio of 50:50 while Clifton Products Inc use 13 to 15 pct beryllium chloride with the balance a mixture of equal parts sodium and potassium chlorides. In the latter case the electrolysis proceeds to a point just short of completion when the entire contents are poured into another vessel and allowed to solidify. The metal in the form of flakes tends to collect in the lower part of the salt from which it is separated by leaching while the remaining salt is returned to the cell. The German practice is somewhat different, the electrolysis proceeding to a point where the original 50 weight pct. content of beryllium chloride is reduced to 45 pct (it was more usual to start with 54 pct) the metallic flakes which have collected on the side of the cell are scraped out and the molten salt/metal mixture is put in a heated nickel cylinder and a plunger applied to cause the molten salt to exude leaving metal with a relatively small amount of salt which is leached in iced water to prevent the hydrolysis of beryllium chloride. The metal flakes are finally washed with caustic soda and nitric acid, centrifuged and air dried.

In Germany, and presumably in France (the plant operated in France was evacuated from Germany), the electrolysis was performed in a nickel crucible which formed the cathode while a central graphite rod was the anode. The charge was heated by a metallic resistor.

The Clifton Products Inc arrangement is rather different; the cell which forms the cathode is cast from alloy steel of high nickel-chromium content with a molybdenum grain refiner. The anode is a thick graphite rod. The crucible and contents are heated by oil firing. In the German practice the electrolysis was performed at 350°C while the American arrangement operated at 760°C to 790°C.

Detailed analysis of the German beryllium metal is not available but a typical analysis of material produced by a similar process is given in Table III.[8]

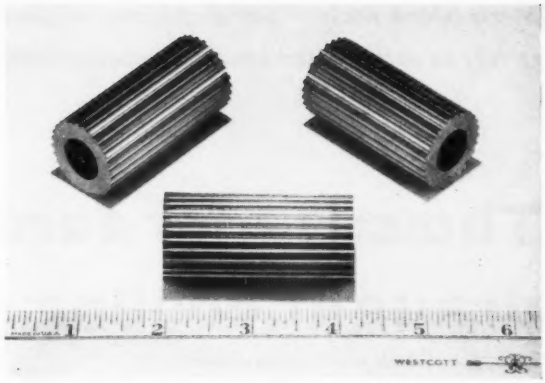
Table III

Typical analysis of electrolytic beryllium

Electrolysis Run	A	B	C	D
Ag	*A10 p.p.m.	A8 p.p.m.	A6 p.p.m.	
Al	†L30 p.p.m.	L30 p.p.m.	L30 p.p.m.	
B	A0·5 p.p.m.	A0·5 p.p.m.	A0·5 p.p.m.	
Ca	L100 p.p.m.	L100 p.p.m.	L100 p.p.m.	
Cd	L1 p.p.m.	L1 p.p.m.	L1 p.p.m.	
Cr	A6 p.p.m.	A6 p.p.m.	A6 p.p.m.	
Cu	A60 p.p.m.	A60 p.p.m.	A60 p.p.m.	
Fe	A30 p.p.m.	A180 p.p.m.	A90 p.p.m.	
K	A60 p.p.m.	L30 p.p.m.	L30 p.p.m.	
Mg	L30 p.p.m.	L30 p.p.m.	L30 p.p.m.	
Mn	A30 p.p.m.	A100 p.p.m.	A150 p.p.m.	
Na	A1500 p.p.m.	A100 p.p.m.	A100 p.p.m.	
Ni	A150 p.p.m.	A150 p.p.m.	A150 p.p.m.	
Pb	A50 p.p.m.	A50 p.p.m.	A50 p.p.m.	
Si	L30 p.p.m.	A30 p.p.m.	L30 p.p.m.	
Sn	A8 p.p.m.	A10 p.p.m.	A10 p.p.m.	
Zn	A30 p.p.m.	A30 p.p.m.	A30 p.p.m.	
O	—	0·4%	—	
Cl	—	—	—	A250 p.p.m.
C	—	—	—	0·10%
N	—	—	—	0·001%
Assay	98·4 pct	99·47 pct	99·48 pct	

*A=approximately †L=less than

It is stated[11] that although the electrolytic process can produce extremely pure beryllium, experience has so far indicated that powder made from flake contains enough salt to cause difficulties in fabrication. It is also pointed out that the chloride tends to hydrolyse forming beryllium oxychloride which is insoluble in the electrolyte and therefore contaminates the metal produced. A recent investigation at Harwell[12] proved that beryllium metal produced by reduction of the fluoride or by electrolysis of fused chloride produced massive metal with similar properties, provided that the electrolytic flake was treated to remove chlorides.



Hot pressed cylinders in Brush Beryllium QMV powder

The Harwell investigators found that the chloride was not present as a simple chloride, e.g. leaching in water and heating the metal *in vacuo* to just below the melting point and beryllium did not affect the chloride content. It was found eventually that oxalic acid was the most suitable leaching agent.

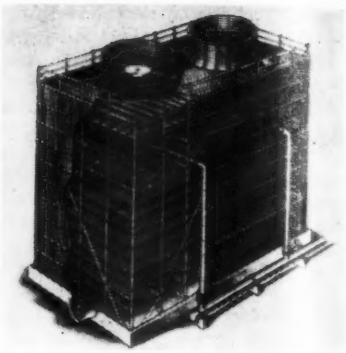
To be continued

References

1. B. R. F. Kjellgren, *Status of the Beryllium Industry in the USA*, Paper delivered to the Institute of Metals, London, March, 1957
2. G. L. Miller, *Beryllium and Zirconium*, The Times Review of Industry, April, 1956
3. Mineral Industry Surveys, US Dept. of the Interior, Bureau of Mines, Mineral Market Report MMS No. 2553
4. H. T. Reno, *Beryllium*, Bureau of Mines Minerals Yearbook, 1954
5. N. W. Bass, *The Rôle of Beryllium in Industry*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
6. P. S. Bryant, *Beryllium Production at Milford Haven*, Inst of Min & Met Symposium for the Extraction Metallurgy of some of the Less Common Metals, London, March, 1956
7. *Investigation of Beryllium Production in Germany and Italy, including production and uses of oxides and alloys*, BIOS Final Report No 550, Item No 21, HMSO, London, 1945
8. C. E. Windecker, *The Production of Beryllium by the Electrolysis of Beryllium Chloride*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
9. C. W. Schwenzfeier, jr, *The Sulphate Extraction of Beryllium from Beryl*, The Metal Beryllium, D. W. White, jr, and J. E. Burke, Editors, The American Society for Meta's, Cleveland, 1955
10. L. J. Dereham, D. A. Temple, *The Preparation of Beryllium Metal by Thermal Reduction of the Fluoride*, Inst of Min & Met Symposium for the Extraction Metallurgy of some of the Less Common Metals, London, March, 1956
11. A. R. Kaufmann, B. R. F. Kjellgren, *Beryllium Technology*—USA, Peaceful Uses of Atomic Energy, Proceedings of the International Conference in Geneva, August, 1955, Vol 8
12. J. Williams, *The Powder Metallurgy of Beryllium*, Beryllium and Zirconium. Progress in Nuclear Energy, Series V, Metallurgy and Fuels Vol 1, Editors H. M. Finniston and J. T. Howe, 1956
13. P. Corzine, A. R. Kaufmann, *The Melting and Casting of Beryllium*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
14. D. W. Lille, *The Physical and Mechanical Properties of Beryllium Metal*, The Metal Beryllium, D. W. White, jr, and J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
15. B. R. F. Kjellgren, *Beryllium*, Rare Metals Handbook, C. A. Hampel, Editor, Rheinold Pubg Cpn, New York, 1954
16. W. W. Beaver *Fabrication of Beryllium by Powder Metallurgy*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
17. E. A. Gulbransen, K. F. Andrew, *The Kinetics of the Reactions of Beryllium with oxygen and nitrogen and the effect of oxide and nitride film on its vapour pressure*, Jnl Electrochem Soc, **97**, 11 (1950) 383
18. R. F. Koenig, *Corrosion of Beryllium in Liquid Metals*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
19. *Reactor Design and Power Costs in the Future*, Sir Christopher Hinton, Atom No 6, April, 1957, UKAEA
20. L. Stone, *Beryllium offers High Structural Promise*, Aviation Week, December 17, 1956, p. 57
21. G. A. Hoffman, *Could Beryllium be used as a Structural Material?*, Materials & Methods, February, 1957, p. 100, Vol 45, No 2

Many inland nuclear power stations will have to rely on recirculated condenser cooling water

The case for forced-draught cooling towers



A 2-cell 'Counterflo' forced-draught cooling tower in timber. The DIDO/PLUTO reactors in the UK and abroad use similar units with eight cells for light water cooling. They are built by Head Wrightson under licence from the Fluor Corporation of America

DEREK J. TOW BSc(Eng). AMIMechE. AMIChemE
Head Wrightson Processes Ltd

THE GENERATION of electricity in this country for many years to come, whether from conventional or nuclear power stations, will be carried out by means of steam driven turboalternators. To obtain high thermal efficiency these alternators require the turbines to exhaust to condensers under vacuum. Naturally, if industrial needs allow, the generation station will be located near a large source of water—sea, river, canal, etc—which may be used directly for condenser cooling with the heated water then being passed to waste.

Increasingly, however, the new power stations, particularly the nuclear type, will need to be located near the centres of industrial activity. The water for condensing will then be cooled in cooling towers in a closed circuit.

In precast concrete for a Government department, this 16-cell 'Counterflo' tower cools four million gallons of water an hour through 24 deg F. John Laing and Son carried out the civil engineering

In this system the heat removed from the condensers is passed to the atmosphere, partly by the evaporation of steam from the water and partly by direct heat-exchange with the air.

A great deal has been written in the press recently about the danger of reactor runaway and the consequent danger that this may cause to the population. It would seem therefore that, when considering nuclear power stations for the industrial areas of Britain, the Central Electricity Authority must consider siting these stations some distance away from the industrial centre, presumably in park, forest or even marsh. When selecting such a site from the safety point of view the amenities of the power station in relation to the surrounding country must be considered.

This raises the question of whether the cooling towers should be of the natural or mechanical draught type. In this connexion it is interesting to note that modern mechanical induced draught cooling towers have been selected at the Hackney 'B' conventional power station of the CEA. These towers are extremely small in size, particularly in height, compared with the comparable natural draught towers. For instance, the induced draught cooling tower supplied at Hackney is 289 ft long, 37 ft wide and 36 ft high, whereas the equivalent natural draught tower would have been 160 ft in ground diameter, 110 ft in outlet diameter and 230 ft high.

In addition, of course, mechanical draught towers are free of the rigid discipline imposed by the necessary chimney structure of a natural draught tower and are therefore more subject to sympathetic architectural treatment. Another advantage which arises from the low height and inconspicuous nature of the mechanical draught tower is the ease of camouflage in wartime and the fact that the towers are not of a height to cause obstruction to aircraft.

Finally, the question of ground loading has to be considered. If the new power stations, whether conventional or nuclear, are sited in areas outside the industrial centres, it is possible that land of low bearing capacity may be the best available. Although extensive foundations will be required for the reactor building in the case of the nuclear stations, there is no need to have such foundations for the towers. The low weight of the mechanical draught cooling tower makes it extremely suitable for projects of this nature.

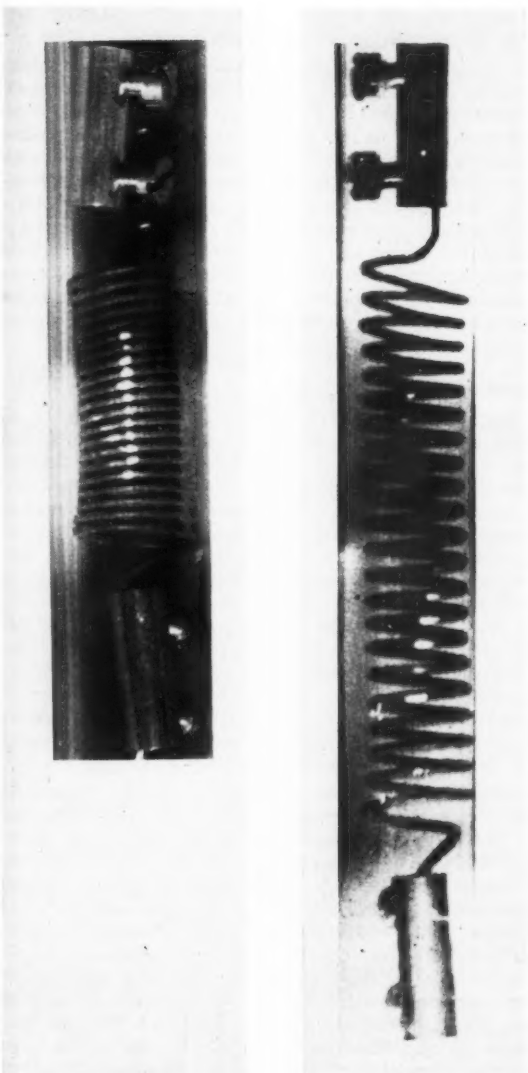
All the above factors have been considered during the provision of a conventional power station for the large electricity concern in Germany, Rheinisch-Westfälisches Elektrizitätswerk, who have recently ordered a considerable number of induced draught cooling towers based on UK designs.

On economic grounds the difference between the two types of towers is not so marked, but on the grounds of amenities there is an extremely strong case for the use of mechanical draught towers instead of the large hyperbolic structures that are seen dotted around the country.

In Britain's new power stations, initial fuel charge will cost half as much again as the reactors. Reducing this is primarily the job of the metallurgist

NUCLEAR ENGINEERING MATERIALS

International conference at Aldermaston



Taken by infra-red light, photographs illustrate work by A. C. Roberts (Harwell) on the influence of irradiation on uranium creep. On the left is a loaded spring before irradiation; right, the same spring after ten weeks' irradiation in BEPO at 100°C

THE RESEARCH laboratories of Associated Electrical Industries Ltd at Aldermaston Court were the setting for a conference in July on materials for nuclear engineering. Organized jointly by the firm and the Physical Society, the conference was attended by 130 delegates from France, Germany, Japan, USSR, Sweden and Turkey who were welcomed by AEI's research director, T. E. Allibone.

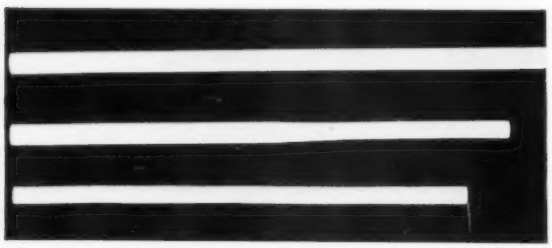
On the creep of materials under irradiation, A. H. Cottrel (Harwell) said all structural materials absorb neutrons to some degree, and are stressed to the limit during the processes of fission and heat removal which impose large stresses on all reactor components. One neutron collision, he said, could 'melt' a million atoms, one fission a thousand million atoms; yet early experiments failed to detect any influence of irradiation on creep. Thus there is a good case for theoretical evaluation of irradiation problems so that only critical experiments need be done. He showed that the direct effect of vacancies and interstitials is small compared with thermal agitations of the atoms and surveyed less direct effects which might be important. Fine precipitates in some alloys are dispersed by irradiation, and this would remove one source of creep resistance, solid solution hardening being more valuable in this respect. Internal friction measurements on samples irradiated for only 10 minutes in BEPO show that point defects effectively anchor dislocations and produce radiation hardening. A dominant role was ascribed by Cottrell, however, to internal stresses which could equally well arise from thermal gradients, thermal fluctuations or irradiation effects in anisotropic materials—notably, of course, natural uranium—and he demonstrated that in all these fields a theoretical appreciation of the problem had led to a greatly improved understanding of the observed effects.

Diffusion of fission product gases

Studies of the effect of irradiation on the optical properties of insulating crystals were described by Professor Ditchburn (Reading University). He showed, for example, that prior neutron irradiation greatly increases the effect of X radiation by displacing atoms as well as exciting electrons, providing colour centres where the X rays themselves subsequently excite electrons. In a striking optical change in synthetic crystalline quartz segregate areas of aluminium present only to the extent of a few parts in 100,000 could be clearly seen as prisms under the microscope. Another typical experiment showed by the use of polarized fluorescence the orientation of defects in diamond along the directions of the tetragonal bonds and of the tunnels between atoms in the (110) direction.

Beryllium, when neutron irradiated, produces three gas atoms for every atom destroyed; uranium can produce 30

volumes of gaseous fission products (measured at NTP) in 3 years operation in a typical reactor. These figures were given by R. S. Barnes (Harwell) and A. T. Churchman (AEI laboratories) in a paper on the production of gas in solids by irradiation. Boron-10 produces large quantities of helium which will reduce the carbide to granules by the time one-third of the atoms are destroyed. Studies of irradiated materials have afforded a qualitative understanding of the behaviour of the gases produced. At low temperatures, the low diffusion rate causes the nucleation of



Photograph: J. E. Antill (Harwell)

Effect of zone sintering on alumina-based refractory rod:
(top) before sintering
(centre) partially sintered rod shows change of thickness at the middle; note freedom from cracking despite thermal gradient
(bottom) fully sintered rod; zone temperature 1650°C, zone width 2in., zone speed 12in./h

many small bubbles whose size is controlled by surface tension forces. At higher temperatures, a smaller number of large bubbles nucleate, expanding at a rate determined by the strength of the matrix at that temperature.

Plutonium toxicity is such that one good-size plutonium dust particle retained in the body represents the safe dose for a lifetime, according to M. B. Waldron (Harwell). This necessitates the use of special glove boxes for all work and hence the tendency has been towards simple experiments. Waldron traced the progressive realization over a period from 1944 to 1955 of the complex allotropy of plutonium, now known to have six phases below its melting point at 640°C. He showed that most of its physical properties are anomalous—for example, the negative expansion coefficient of the cubic delta-phase. The alloying behaviour is similar to that of uranium, but significantly different owing to the complex configurational behaviour of the electrons.

Stored energy in graphite

Lack of success in obtaining pure beryllium still prejudiced the question of its inherent brittleness, in the opinion of G. C. Ellis (AWRE) who reviewed the status of beryllium metallurgy. In support of this, he cited the existence of repeated yield points and of pseudo-allotropy in the material at present available. The deformation behaviour of beryllium is very dependent on its mechanical treatment, useful ductility in two directions being obtainable. This behaviour could be related successfully to the crystallographic properties of the material. The author's optimism was tempered by reference to its difficult extraction, its brittleness in cast or welded conditions and its toxicity.

Calorimetric studies by G. B. Greenough (Windscale) of the stored energy released on heating graphite showed that the stored energy increased continuously with irradiation over the range examined (equivalent to 3000 MWD/Te of uranium) attaining 600 cals/g; annealing at 1000°C only released a fraction of this energy. On heating to successively higher temperatures there is a maximum in the energy release curve at 200°C, most noticeably after 650 MWD/Te burnup. These results had been interpreted in terms of the formation of local defect pairs.

Additives for liquid metals

Wetting of solids by liquid metals is an important factor in both the corrosion of circuits and the properties of slurry fuels, although solution in the liquid and mass transfer can occur without complete wetting according to B. R. T. Frost (Harwell). He stressed the importance of small additives, sometimes to break down oxide films when wetting was required, or to form protective layers, as in the case of zirconium in bismuth which reacts with the nitrogen in steels to form a nitride layer. Mass transfer is also inhibited by unfavourable nucleating conditions in the cooler parts of a circuit. One striking case of transfer is the formation of an aluminium copper compound layer in bismuth well separated from either of the two parent metal components.

An interpretation of the structures of the elements from rubidium to silver, the rare earths and the transuranic series, was proposed by Dr Friedel (Ecole des Mines, Paris) supported from the few known properties, thus suggesting interesting possibilities for those which remain to be determined. In the transuranic elements he suggested predominantly 'transitional' behaviour as far as thorium, with a subsequent trend to rare earth behaviour, most marked in americium, which has a characteristic double hexagonal crystal structure. In the intervening elements a strong tendency to hybridization of 5d and 6f bonds would give directional bonding, noticeable in the low temperature modifications of these elements.

Plutonium recycling

In language slightly more familiar to metallurgists, G. K. Williamson (AERE) discussed some aspects of solid solution and intermetallic compound formation for alloys of these elements. He demonstrated that the rules propounded by Hume-Rothery for simpler metals were still obeyed in principle. The way that plutonium dissolves in thorium suggests that the factors underlying these rules are very powerful. Thus, the plutonium atom adopts the size which corresponds to a four-valent state and is also favourable for solid solution rather than adopting either of the two configurations found in the cubic forms of the pure metal. Williamson proposed that the puzzling occurrence of immiscibility gaps in the gamma-phase solid solutions of uranium could be systematized in terms of an interplay between the strain energy introduced by the solute atoms and the temperature-dependent entropy of mixing.

Closing the conference, Sir John Cockcroft stressed the need for maximum operation of the fuel by saying that the fuel cost for a recent 360 MW (gross) reactor design amounted to £M9—more than half the capital cost. Among the recent developments which promise well for reactor development are zone-sintering of ceramics, beryllium clad elements, which withstand 1000 cycles through the alpha/beta-uranium phase change, and the development of all-ceramic fuels for the high temperature gas-cooled reactor at an operating temperature of 800°C. Many of the possible developments call for enriched fuels and the possibility of recycling plutonium as an enrichment is an attractive alternative. Sir John said that present improvements would raise the thermodynamic efficiency of nuclear power stations from 25-28% to 30 or 33%. If the problems associated with the liquid metal or aqueous homogeneous reactors could be solved, these promise to be extremely low cost power producers. **M. B. Waldron**

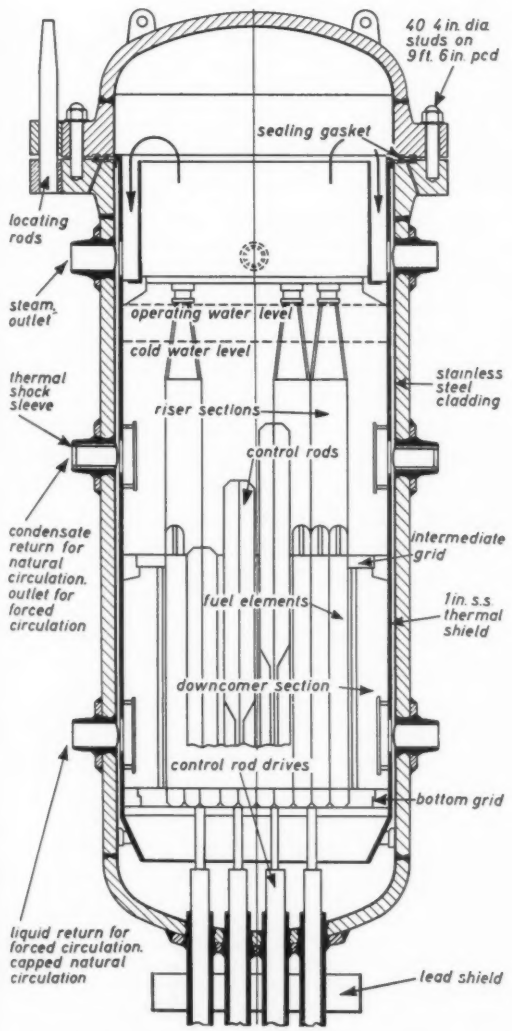
A British firm will play a major part in building Germany's first nuclear power plant

THE RWE-ATOMKRAFTWERK KAHL

a closed-cycle boiling-water reactor

H. J. COLES, AMIMechE, AMIMarE,

Chief Engineer, Nuclear Power Division, Mitchell Engineering Ltd



The core pressure vessel for 1200 psig will be about 25ft high. Circulation in the vessel is entirely by natural convection but provision is made for forced circulation if required. Cross-type control rods are actuated from below. Normally held above the core, they are designed to fail safe

A CLOSED-CYCLE, boiling water power plant is now under construction near Frankfurt am Main for the Rheinisch-Westfälisches Elektrizitätswerk AG by the American Machine and Foundry Co, New York, and Mitchell Engineering Ltd, London, in association with Siemens Schuckertwerke AG, Erlangen. With a thermal output of 58MW supplying a 17MWe turbine, the reactor will be very similar to that being constructed by AMF at Elk River, Minnesota, for the Rural Cooperative Power Association but whereas this plant will take steam from an oil-fired superheater, the RWE will use it saturated. Site work commenced in July 1957 and the whole plant is due for commissioning in October 1959.

Designed for economy

This plant is considered a logical step in the development of a type of nuclear power plant to compete with conventional power stations of comparable size. Nevertheless the designers have aimed at the outset to provide power on a reliable basis at an economically justifiable cost and moreover to construct a plant with such built-in design features that will enable the operators to obtain as much knowledge and experience as possible.

A site immediately adjoining the RWE power station at Dettingen has been selected and the atomic power station will be named *RWE-Atomkraftwerk Kahl* after the nearby village of Kahl. Adequate cooling water supplies will be available from the R. Main—even allowing for a later extension of the station—and the site is also favourably situated from a point of view of power demands.

Preliminary studies showed that heavy water as a moderator and coolant might be more economical than light water in reactors of this type for an output above about 50MWe. For the size envisaged, however, light water was preferable on cost grounds. The boiling water system was chosen because it was considered the most economical of all proven methods of heat removal.

After weighing the pros and cons of direct- and closed-cycle systems it was decided to use the latter. A direct steam supply to the turbine, as on Argonne's EBWR would provide a higher pressure at the stop valve and would eliminate intermediate heat exchangers but it was considered that these would in fact be advantageous because they would provide additional lag and damping to the system and so improve plant response to load changes. Also the turbine, condenser and feed heaters would not receive radioactive steam and so could be outside the shield and accessible at all times. Further advantages claimed for the closed-cycle system are: auxiliaries can be steam-driven which could be of importance in marine

and direct heat applications; the adaptation for use with heavy water is relatively simple.

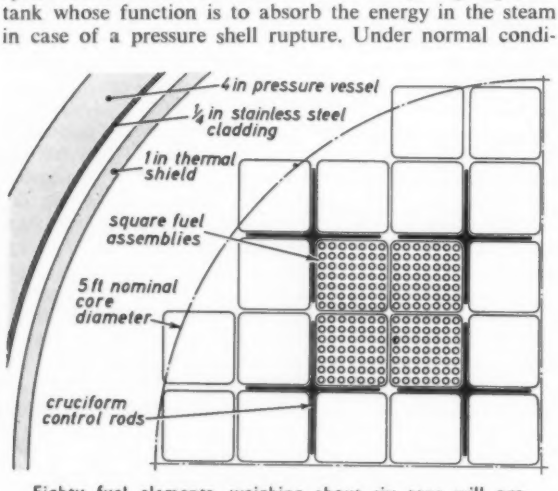
Flexible layout

Throughout the design, emphasis has been placed on flexibility and so provision has been made for an additional turbine, forced-circulation pumps, additional heat exchangers and sub-coolers should they ever be required. The shielding has been designed to accommodate a substantial increase in output, and the core arrangements are such that it can be removed and replaced by a new one should technological advances make this desirable.

The plant layout will be clear from the large coloured drawing in this issue of NUCLEAR POWER. The whole of the primary system and biological shielding will be within a steel shell 47ft 6in. dia, 110ft high. The cylindrical portion will be 62ft 6in. high and of $\frac{1}{8}$in. mild steel plate. The hemispherical ends will be of $\frac{3}{8}$in. plate. Designed to German standards, the containment shell will withstand 30 psig. Access to the interior will be by airlock but a door is also provided for removal of fuel coffins.

Reactor below ground level

The containment shell will be partly below ground and largely filled with concrete inside, with chambers for the reactor pressure vessel, the heat exchangers and the used fuel storage tank. It is proposed to erect the shell on temporary legs inside a concrete-lined pit and fill outside simultaneously with the inside. The reactor chamber will be 13ft 6in. dia, about 32ft high: it will be lined with 1in. steel to act as an additional containment and thermal shield. The four heat exchangers are arranged round the core in an annular chamber cast in the concrete and below these will be mounted the four sub-coolers which adjust the temperature of the primary water before it is returned to the core. This annular space also includes a separate chamber containing a tank for the temporary storage of spent fuel elements. Further below is a 50,000 gal quench tank whose function is to absorb the energy in the steam in case of a pressure shell rupture. Under normal conditions, it will be used for draining the reactor vessel shield after it has been flooded for recharging. The lowest chamber in the shell contains the control rod motors and access will be provided right down to this level.



Eighty fuel elements, weighing about six tons will provide 58MW of heat. Quarter section through core shows disposition in pressure vessel

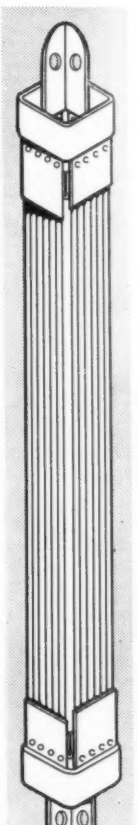
The reactor is designed for a heat output of 58MW and 241,000 lb/h of steam generated in the core will be passed at 900 psig, dry sat. (533°F) to the four concentric tube heat exchangers. Here, the radioactive primary steam exchanges heat with secondary water and 224,000 lb/h, also at 900 psig dry sat. is passed out of the containment shell to a steam separator and from thence to a 17MW two-cylinder tandem turbine directly coupled to a 20MVA, 6kV, alternator in the adjacent power house. Five stages of feed heating will be provided, raising the secondary water to 350°F. Steam dumping when required will be done in the main condenser, a turbine bypass being provided.

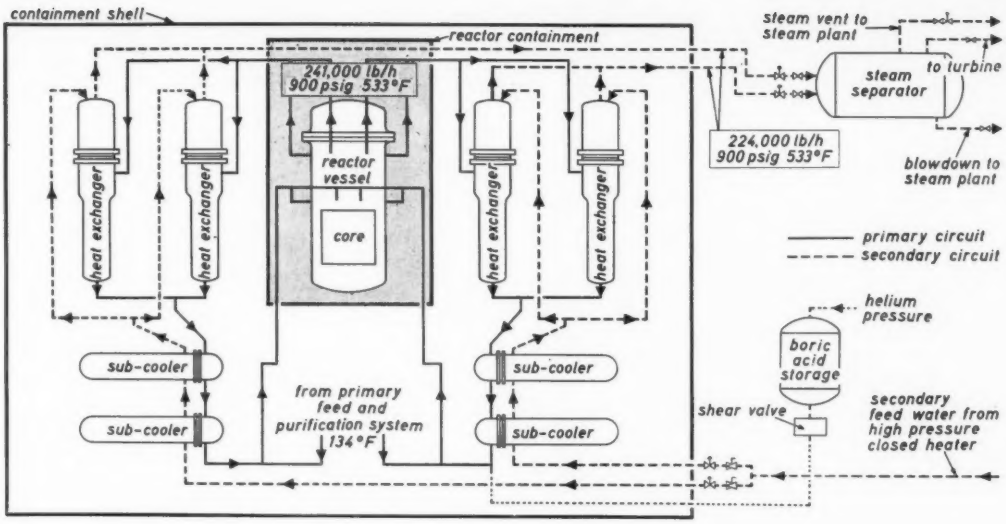
Oxide fuel elements

The core will comprise 80 4·468in. square fuel assemblies each containing 49 rod-type elements arranged 7 × 7 on 0·592in. square pitch. These will consist of Zircaloy tubes with 0·030in. walls, filled with short 0·425in. dia cylinders of sintered uranium oxide and thorium oxide. End closure of the tubes will be by welding. The object of the thorium is of course to breed U-233. Thorium oxide makes up 75 pct of the charge and uranium oxide enriched to 10 pct in U-235 to give an excess reactivity of 6 pct accounts for the remaining 25 pct. Total weight of the core including the cladding will be about 6 tons. The active sections of the fuel elements are 5ft high and the core assembly approximates a right circular cylinder of this height and the same diameter. The actual arrangements of the assemblies is 4, 8, 8, 10, 10, 10, 10, 8, 8, 4. Riser sections 5ft in height are provided above the four active sections of the core to increase the natural circulation.

Advantages of oxide as fuel

Although the early nuclear reactors such as Fermi's 1942 pile and Harwell's GLEEP used uranium in the form of oxide, as metal became available in quantity it became increasingly used as it is much more dense, enabling more fissionable material to be contained in a given space. Now however—particularly with enriched uranium—oxide is being again considered as a fuel. Uranium metal has definite limitations as to the maximum temperature it can stand and the period it can be left in the reactor without unacceptable distortion due to repeated temperature changes and nuclear irradiation. Oxide has a much higher melting point, does not change its structure with rising temperature and is believed to be more resistant to radiation. In the RWE reactor the fuel will be in the form of short sintered rods of enriched uranium oxide contained in tubes of zirconium alloy. This resists the corrosive effects of high temperature water and will contain the reactor poisons which arise as a result of fission of the uranium. Forty-nine tubes will form a complete fuel element.





Unique feature of the AMF-MEL plant is that radioactive steam never leaves the containment shell. Instead, it is exchanged with secondary steam in four heat exchangers thus permitting full access to the turbine at all times. Boric acid system is used for shut down in extreme emergency

Ceramic fuel elements were chosen by AMF Atomics—who are responsible for the nuclear side—for their dimensional stability under irradiation and their inertness under chemical attack by degassed water and steam. The elements are claimed to be completely isotropic with respect to processing and fabricating history and undergo no allotropic phase changes up to the melting point. The maximum temperature at the centre of the core will be less than 3200°F and the corresponding temperature at the interface with the Zircaloy can, less than 800°F. At this temperature the diffusion rate of UO_2 into Zircaloy is negligible. Surface temperature of the cans will be less than 565°F. The very steep gradient in the oxide is of course due to its poor thermal conductivity.

At the core centre the maximum heat flux will be 150,000 Btu/h/sq ft and the average value, 114,000. The average volume of steam in the water channels of the fuel assemblies will not exceed 13 pct of the total water channel volume when the reactor is delivering 58 MWt. Mean thermal flux will be 3×10^{13}.

Stainless steel clad pressure vessel

The core assembly is contained in a 4in. thick cylindrical pressure vessel designed for 1200 psig. It will be in carbon steel type SA212B clad internally with $\frac{1}{4}$in. stainless steel type 304L. Inside diameter will be 90in. and complete with removable head the whole vessel will be about 25ft high. Inside, a 1in. thick stainless steel thermal shield will be fitted which will also act as a core basket from which the three main grids of the core will be supported. The space between the shield and vessel wall acts as the downcomer section.

The forged head will be removable to give full-way access and will be bolted through a flange on the vessel, the whole assembly being designed to German standards for pressure vessels. Sealing will be by stainless-steel-covered gaskets incorporating a leakage detection device. Primary steam will be taken out through four 8in. branches and internal fittings will ensure a reasonable dryness of the steam at exit. Four 6in. branches in the downcomer section of the vessel return condensate from the sub-coolers and should forced circulation be required later, four similar branches will be fitted at the bottom of the downcomer section for return connexions. Under natural circulation these will be used for feed make-up and the purification loop return take off.

Rod drives from below

The bottom of the vessel will be fitted with sixteen tubes (4×4) for the control rods. These rods are of cruciform section with blades $\frac{1}{4}$in. thick and 11in. span. They will have a stroke of 54in. and will be driven by electro-mechanical actuators. The four centre rods will contain hafnium and will be used for fine control. The outer rods —borated stainless steel—are for shut off and safety. In normal operation, the rods are held out above the core and reactivity is reduced by lowering them.

On receipt of a scram signal, the rods are dropped into the core by gravity, assisted by a stored energy system and thus fail safe. The drive mechanisms are irreversible and have magnetic couplings which are de-energized on a scram signal. Decelerating means are provided. Sealing of the rod drives at entry to the pressure vessel is by rotary type seals. The basis of the control scheme will be constant steam pressure.

Underwater fuel charging

When it is necessary to change fuel the reactor is first shut down. The concrete blocks sealing the top of the reactor chamber are removed and the space flooded with demineralized water. The pressure vessel head is now unbolted and lifted aside, thus giving access to the fuel assemblies. These are now withdrawn one at a time and manoeuvred by hand tools into a chute leading through the concrete wall to the spent fuel tank where the assemblies are placed in racks.

After a suitable decay period in the tank the assemblies will be transferred to a transit coffin and removed from the shell through a special door to a rail track. Owing to the fission product heat, the spent fuel compartment is specially cooled. All these handling operations are facilitated by a 20-ton circular motion crane. After charging

operations the flooded chambers are pumped down to the quench tank.

Novel heat exchanger design

The four main heat exchangers are of the concentric tube type arranged vertically. In these the outer tubes are 1in. o.d. 16g stainless steel sealed off at the bottom and held in a tube plate at the top. Inside is a ½in. o.d. by 18g steel tube terminating about 1 inch above the blanked off end of the outer tube. At the upper end the inner tubes pass right through the tube plate to an auxiliary tube plate below the normal water level.

Primary steam enters the exchangers through branches below the head flanges, flows over and round the outer tubes and finally leaves as saturated water at the bottom of the shell. Secondary water is brought in through the top closure and distributed below water level above the auxiliary tube plate. It now flows down the inner tube and back up the annulus becoming evaporated in the process by heat transfer with the primary steam. On arrival at the main tube plate it disengages and is taken off through a centre branch, baffles being provided to prevent priming or carry-over. Circulation, it will be noted is entirely by convection.

The heat exchangers will be in carbon steel to SA212B and clad with ⅛in. type 304 stainless steel wherever there is contact with primary steam. The shell thickness will be 1¼in. over the main length and the overall dimensions about 6ft dia over the flanges and 18ft high overall. The top will be attached to the body of the exchanger by 24 3in. bolts. Primary and secondary sections are designed for 1200 psig in order that in the event of a tube failure the heat exchangers can be sealed off on the secondary side to allow the plant to continue operating at reduced load.

Sub-cooling of primary condensate

The main heat exchangers are in effect condensers for the primary steam and only transfer its latent heat to the secondary side. In order to improve the void conditions in the core channels and so enable the vapour fraction at the core outlet to be held at a relatively low level, the return flow to the core has to be sub-cooled below saturation temperature. This is done in sub-coolers and the return flow in the core is thereby adjusted to about 431°F. The sensible heat removed from the primary steam is transferred to the secondary water which is thereby raised to saturation before entry to the main exchangers.

The sub-coolers are of the hair-pin tube type and there will be four, mounted horizontally below the main exchangers. Primary steam will be on the tube side. Materials of construction will be generally similar to those of the main exchangers and the dimensions 2ft 6in. i.d., about 12ft long. These units are coupled in pairs in series, each pair being connected in parallel with two heat exchangers.

All units and pipework in the primary system are designed for 1200 psig and are either solid, or clad with, type 304 stainless steel. Margins have been allowed for possible fouling, but with stainless steel and the standards of water purity to be employed this is considered to be a very long-term risk indeed.

Maintaining purity in primary system

On leaving the heat exchangers the secondary steam is taken outside the containment shell to a horizontal cylindrical steam separator. This will be of welded construction and about 11ft 6in. long by 2ft 6in. dia. A single 10in. branch will lead the dry steam direct to the turbine house. The secondary pipework is also designed for 1200 psig.

Induced radioactivity in pure water is only very short lived but entrained particulate matter emanating from corrosion products can be troublesome and can lead to high build ups with long half-lives. Thus a system of continuous bypass purification has been adopted. Some 5000

How this boiling reactor works

GERMANY'S FIRST nuclear power station is quite unlike those being built in Britain. Instead of using gas for removing the nuclear heat from the core, it uses ordinary water. But to do this it must use uranium which has had its fissionable content artificially increased in special plants in America. The two types of station are not however directly comparable, for the British ones are for generating very large amounts of electricity for the public supply while the plant at Kahl is a much smaller one built mostly for giving German engineers experience in building and operating nuclear plant.

The fuel is contained in long tubes of zirconium alloy made up into assemblies of 49 tubes. Eighty of these are fixed in a grid inside the steel pressure vessel (6) and covered with water. When the reactor is critical—giving out heat—the water is allowed to boil. Some kinds of boiling water reactor use this steam direct in the power turbine but it is radioactive and the Kahl reactor designers have preferred to use non-radioactive steam in their turbine. Thus the primary steam is led through pipes (4) to four heat exchangers (3) in which it gives up its heat to secondary water to produce non-radioactive steam. This is collected in pipe (2) and led off through a steam separator (23) to the 17,000 kilowatt turbogenerator set (36) of conventional design. After use the steam is returned to water in the condenser (35) and sent back to the heat exchanger to be boiled up again. The primary steam is condensed back to water in the heat exchangers, further reduced in temperature in the sub-coolers (5) and returned to the reactor vessel.

Regulation of the nuclear reaction is by rods containing reactor poison. These are operated by electric motors from below the reactor vessel and when they are fully lowered into the core, heat production is stopped and no steam is generated. To start up the reactor, the rods are slowly raised out of the core.

In order to protect the public and the operating personnel all the radioactive parts of the plant are in cells within a massive concrete shield (41) below ground level. Furthermore, a strong steel shell (45) surrounds the whole active volume—even below ground. This will safely contain any steam or gas in an accident.

Numbers here refer to this 3ft by 2ft full-colour cutaway drawing of the closed-cycle boiling-water reactor. Limited copies of this, unfolded, are available from NUCLEAR POWER, price 2s post free

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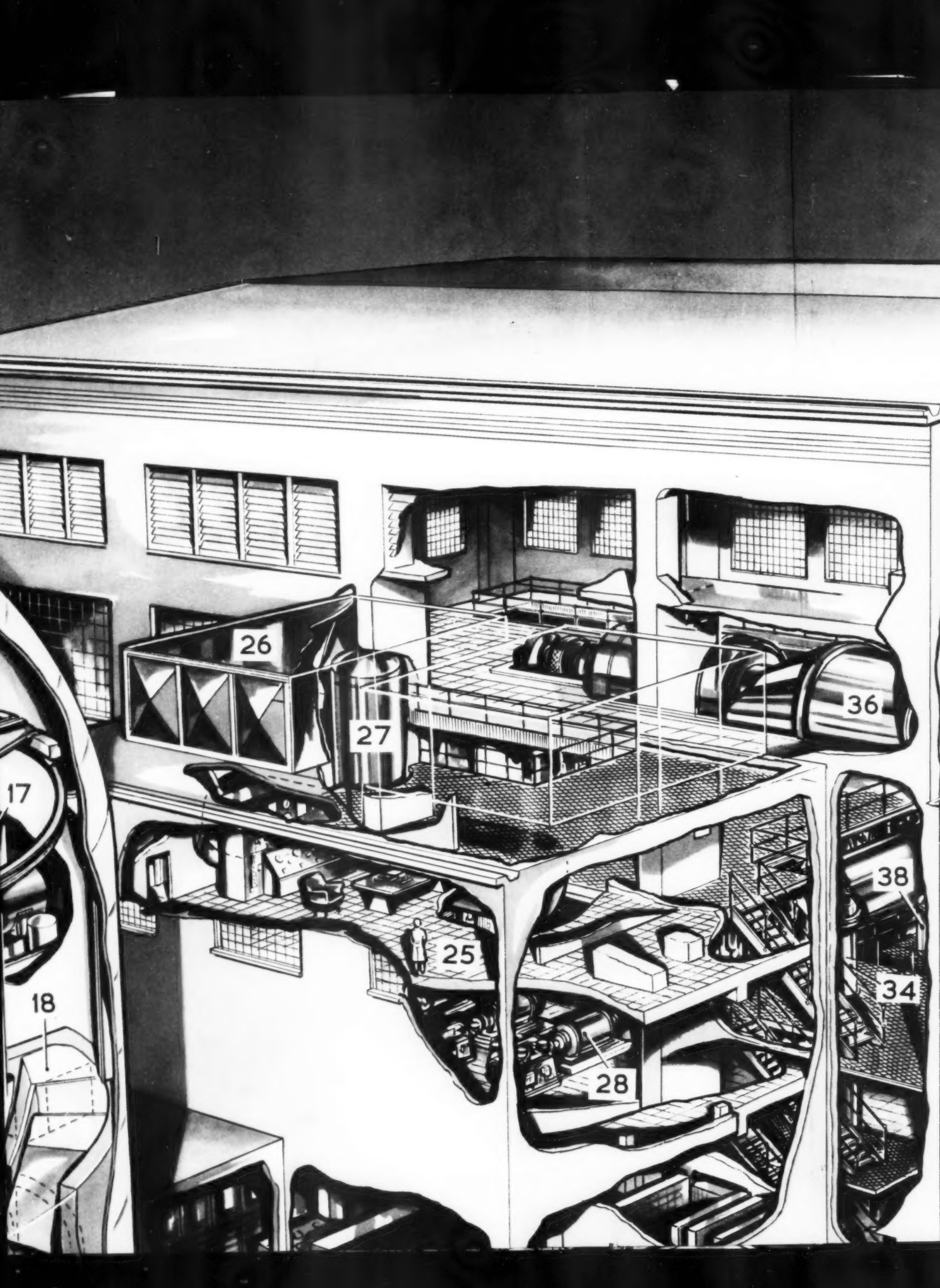
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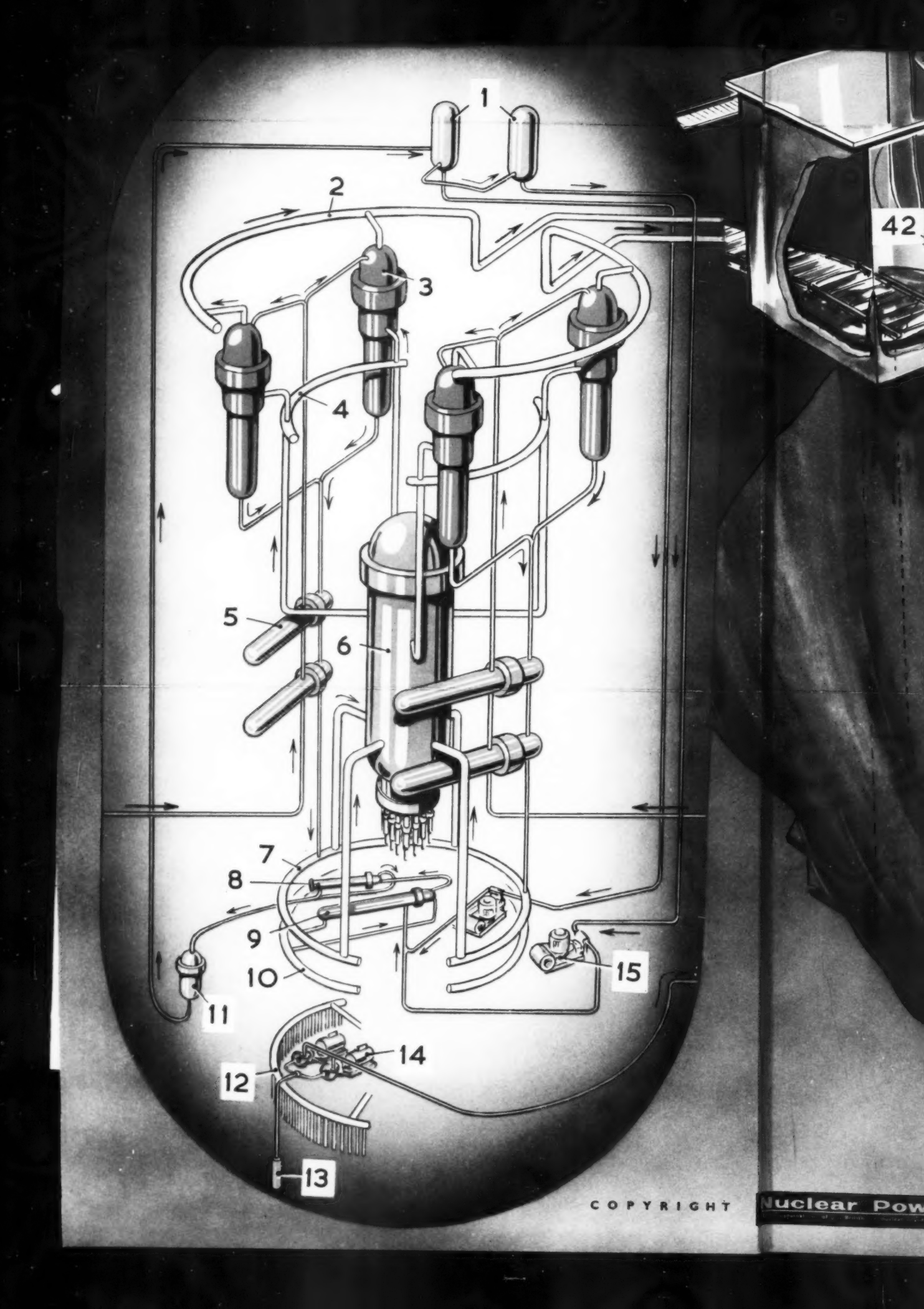
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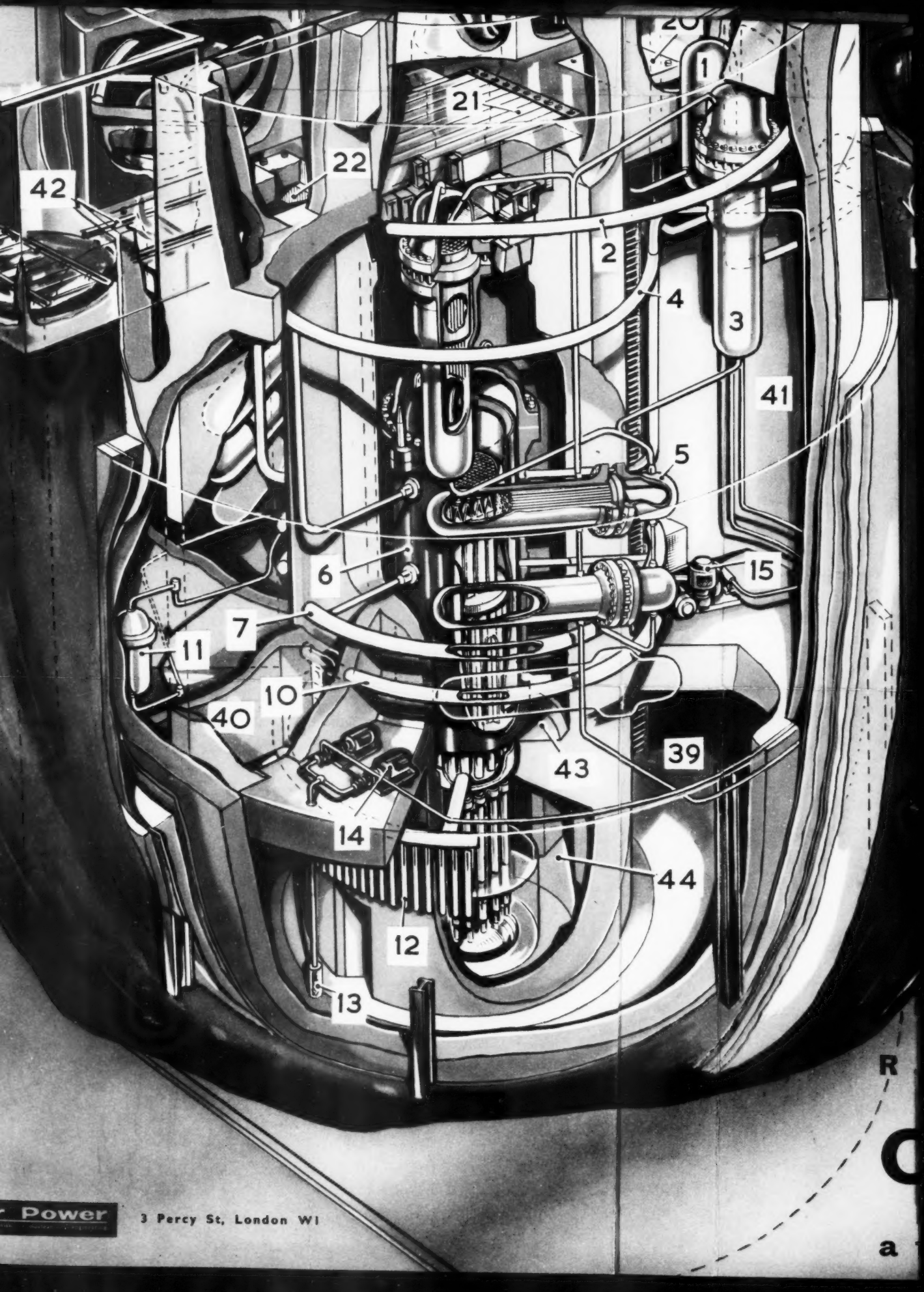

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3 Percy St, London W1

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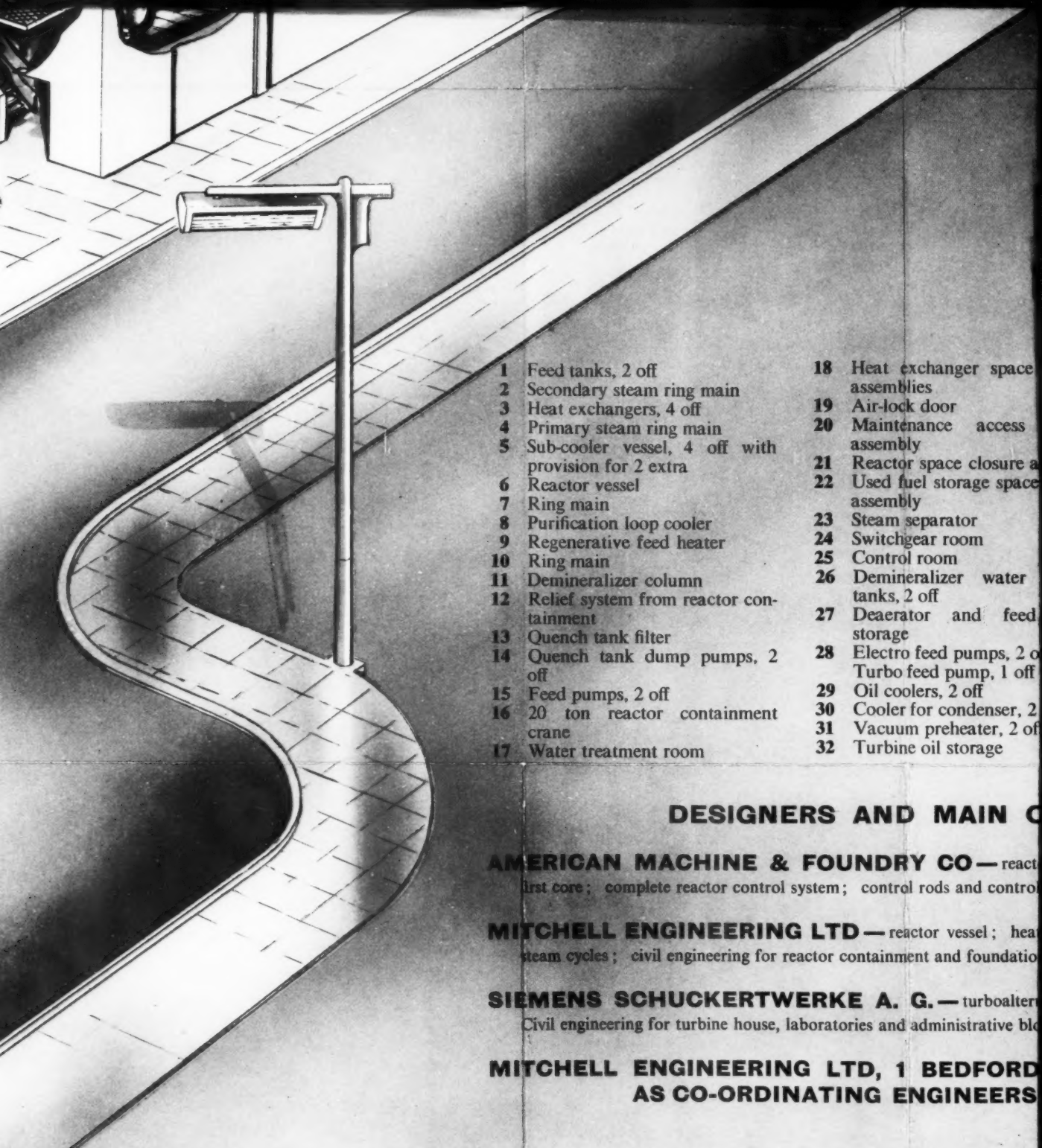

1 Feed tanks, 2 off
2 Secondary steam ring main
3 Heat exchangers, 4 off
4 Primary steam ring main
5 Sub-cooler vessel, 4 off with provision for 2 extra
6 Reactor vessel
7 Ring main
8 Purification loop cooler
9 Regenerative feed heater
10 Ring main
11 Demineralizer column
12 Relief system from reactor containment
13 Quench tank filter
14 Quench tank dump pumps, 2 off
15 Feed pumps, 2 off
16 20 ton reactor containment crane
17 Water treatment room
18 Heat exchanger space assemblies
19 Air-lock door
20 Maintenance access assembly
21 Reactor space closure a
22 Used fuel storage space assembly
23 Steam separator
24 Switchgear room
25 Control room
26 Demineralizer water tanks, 2 off
27 Deaerator and feed storage
28 Electro feed pumps, 2 o Turbo feed pump, 1 off
29 Oil coolers, 2 off
30 Cooler for condenser, 2
31 Vacuum preheater, 2 of
32 Turbine oil storage

DESIGNERS AND MAIN C

AMERICAN MACHINE & FOUNDRY CO — react
first core; complete reactor control system; control rods and control

MITCHELL ENGINEERING LTD — reactor vessel; hea
steam cycles; civil engineering for reactor containment and foundatio

SIEMENS SCHUCKERTWERKE A. G. — turboalter
Civil engineering for turbine house, laboratories and administrative bl

MITCHELL ENGINEERING LTD, 1 BEDFORD
AS CO-ORDINATING ENGINEERS

hes Elektrizitätswerk A.

BOILING WATER R

rt-am-Main, German Federa

18 Heat exchanger space closure assemblies
19 Air-lock door
20 Maintenance access closure assembly
21 Reactor space closure assembly
22 Used fuel storage space closure assembly
23 Steam separator
24 Switchgear room
25 Control room
26 Demineralizer water storage tanks, 2 off
27 Deaerator and feed water storage
28 Electro feed pumps, 2 off
Turbo feed pump, 1 off
29 Oil coolers, 2 off
30 Cooler for condenser, 2 off
31 Vacuum preheater, 2 off
32 Turbine oil storage
33 H.P. preheater
34 L.P. preheater
35 Condenser
36 17MW turboalternator
37 40 ton turbine house crane
38 Water separator
39 Aluminized mild steel lined quench tank
40 Aluminized mild steel lined used fuel storage
41 Heat exchanger space
42 Removable section of rail track
43 Aluminized mild steel lined reactor containment
44 Sub reactor space
45 23ft 9in, 7·25m radius steel shell. Reactor containment building extends 65ft, 21·3m above ground level and 45ft, 13·7m below

ERS AND MAIN CONTRACTORS

FOUNDRY CO — reactor and system design; fabrication and supply of system; control rods and control rod drives; nuclear instrumentation

G LTD — reactor vessel; heat exchangers; sub-coolers; primary and secondary reactor containment and foundations

VERKE A. G. — turboalternator plant and auxiliary equipment; switchgear; laboratories and administrative block

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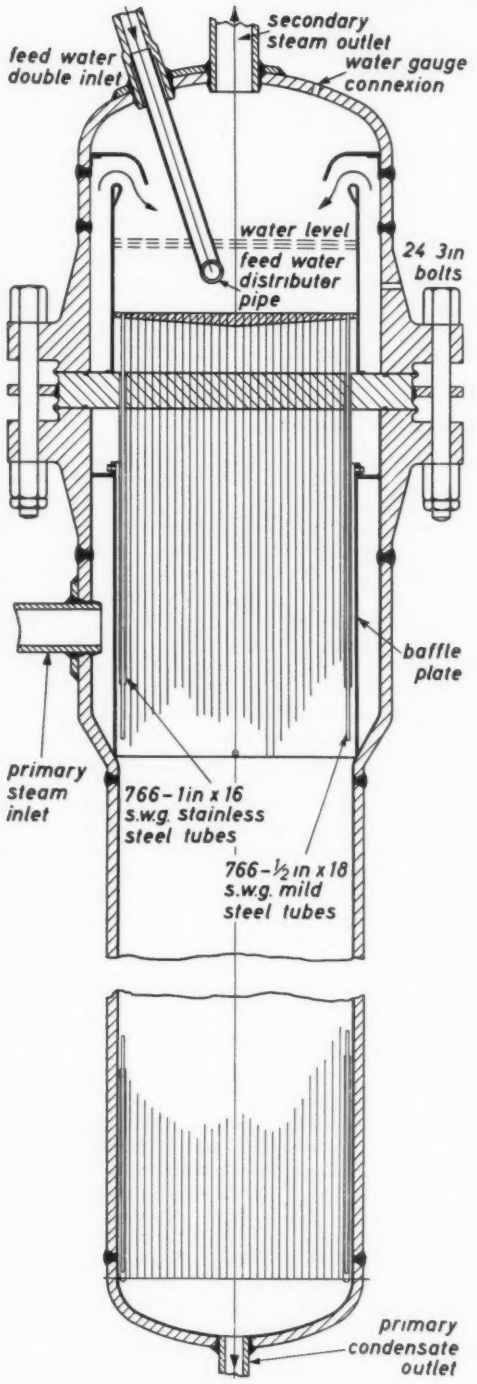


The Kahl heat exchangers are of unusual design. The tubes are in concentric pairs, the outer being blind at the lower end. Secondary water flows down the inner tube and up the annulus while the radioactive primary steam flows around the outside of the outer tubes and leaves at the bottom of the shell

lb/h of primary water are extracted, filtered, demineralized and passed to the primary feed tanks. Located in the purification loop but forming part of the feed system is a regenerative feed heater which extracts some of the heat in the radioactive water and warms clean water. Even this reduction leaves the water too hot for the resins in the mixed bed demineralization plant and so before entry to this unit the water is further reduced to 125°F in the purification loop cooler.

The filters mentioned are of stainless steel and one will be fitted after the ion exchange columns to collect any resins should there be a failure in the demineralizer. The whole of this system is within the biological shield and arrangements are designed for changing the resins by remote control when it is necessary.

Boric acid scram injection

The primary feed tank and feed pump are also inside the shell and are designed to keep the water level in the core at an accurately predetermined level. There will be two pumps—one standby—with a capacity of 5000 lb/h against 1250 psig. All parts in contact with water will be in stainless steel. A comprehensive pressure relief system is also included and the various relief lines lead direct to the quench tank which is designed to reduce the pressure on the containment shell should an incident occur.

An interesting safety measure is the use of a boric acid injection system. The acid is contained in a 50 gal stainless steel tank pressurized by helium from a series of cylinders at 1250 psig. In the event of a power excursion, the boric acid can be injected to the primary system, the boron quickly absorbing enough neutrons to bring the reactor subcritical. To prevent unintended injections the flow is controlled by a shear valve working on excess pressure.

Cooling for containment chambers

As already mentioned, refuelling takes place under water which, after use, is sent to the quench tank. This water will become radioactive after operations and two dump pumps with capacities of 25,000 lb/h are provided to transfer it into a shield water storage tank outside the shell where it will be allowed to cool before discharge to the river.

The primary loop will be fitted with sampling points to allow the conductivity of the water at various points to be measured. After sampling, water will normally be returned to the feed tank within the containment but provision will also be made for samples to be withdrawn for chemical analysis.

Very considerable quantities of heat are released in the various chambers in the shell and comprehensive cooling arrangements will be provided to maintain temperatures at 120/150°F. The main spaces cooled are: the reactor chamber, the heat exchanger annulus, the spent fuel store, the control rod motor chamber and the quench tank. Cooling in these spaces will be by water coils of appropriate capacity arranged in a closed loop system and supplied by three 3 million Btu/h heat exchangers fed with raw water. One of these is sufficient to carry the whole cooling load if necessary. Three 50,000 lb/h, 60ft pumps supply circulation.

Benefit to German industry

Main circulating water—about 6000 tons an hour—will come from the existing RWE station's facilities through a special pumphouse. Make up water will come from a flooded lignite pit nearby.

Numerous German industries will benefit from the new plant since the AMF-MEL group has undertaken to place as many subcontracts as possible with West German firms.

Engineering, Marine, Welding and Nuclear Energy Exhibition

OLYMPIA AUGUST 29 to SEPTEMBER 12

Following last month's preview, a further selection of exhibits with a nuclear interest are described here.

The opening ceremony will be performed by Sir Christopher Hinton at a luncheon on the first day. The exhibition, which occupies the whole of Olympia will be open from 10 until 6 daily (until 8 on Fridays); admission 3/- at the door.

NUCLEAR POWER will be at stand 25, Inner Row, Grand Hall Gallery, and we shall be pleased to see readers there at any time during the exhibition.

Powder classifier for uranium ore

Shown for the first time in the UK by Sharples Centrifuges Ltd (stand D5) will be a new classifier used in the beneficiation of uranium and other ores. Operating on the air vortex classification system, the instrument is claimed to have a very precise cutpoint—for example, five fractions with a top size in the range 15-20 microns contain less than 0·01—0·04% 325 mesh screen residue. Product recovery varies from 80 to well over 90%, depending on product requirements. Standard range of sizes and capacities varies from 250 lb/h to 10 ton/h. The classifier can also be used for 'topping,' and batch or continuous 'tailoring.'

Another new instrument among the Sharples exhibits will be a micromerograph particle size analyser, used in production and quality control and as a research instrument. After deagglomeration by a burst of compressed dry nitrogen, the particles fall through the sedimentation column at their terminal velocities on to a pan of a servo-electric balance. The current through a restoring coil required to keep the beam balanced is a continuous measure of the accumulated weight of powder and is registered on a chart recorder.

Calder condenser plates

The Birmingham Battery & Metal Co Ltd (row BB2, first floor, Empire Hall) supplied 160 tons of material for Calder Hall, including condenser plates weighing 6¼ tons as castings before being rolled. The components will be illustrated in photographic display.

Automatic arc welding

Shown for the first time by Rockweld Ltd (stand U2) will be the *Autopak*, a multi-purpose transformer for both manual and automatic welding. This is a portable power unit housing components for double and single operator manual welding, and for operating a continuous wire automatic welding head. A three-position switch sets the machine for *a*, double operator manual working with current range of 35/325 amp each point, or *b*, single operator manual working with current range of 250/650 amp or *c*, for running the automatic head and supplying it with currents up to 650 amp. On open circuit, 80 volts are provided for manual welding and 60 volts for automatic.

For use with this machine, Rockweld have produced the *Autopoint* automatic head. Light, adaptable and readily mounted for handling bare wire supplied in reels, the head is designed for maximum wire size of $\frac{7}{32}$in. and maximum current of 1300 amp. It may be used with the *Autopak* set for $\frac{5}{32}$in., $\frac{1}{4}$in. and $\frac{5}{32}$in. wire, or with two in parallel for $\frac{1}{16}$in. and $\frac{7}{32}$in. wire. Feature of the head is the double motor drive geared differentially to the feed rolls and regulated by a circuit which is extremely sensitive and responsive to arc conditions. The arc is self-starting, and the system is immune to variations in supply voltage.

Charge pan for GEC station

APV Paramount Ltd (stand K11) will have on show one of several hundred steel castings they are supplying for the General Electric Company nuclear power station. They form the charge pans through which the control rods are lowered into the core. Weighing about 800 lb each they demand castings of high quality and dimensional accuracy.

Pneumatic control equipment

Several examples of this type of equipment will be shown by the Westinghouse Brake & Signal Co Ltd. Part of the stand will contain a three-section display board illustrating how pneumatics can provide a safe, clean and positive acting remote-control system, well suited to the control of nuclear energy production. The systems include various specialized units such as multi-position cylinders giving distinct and accurate positioning. Pneumatic servo power devices for accurate positioning against heavy loads are also available, and working examples of these will be shown.

Model of nuclear submarine

On the Admiralty's stand (BB 9) a nuclear propulsion unit will be demonstrated in a sectional model of a submarine, with an animated arrangement to indicate the water and steam flow and mechanical transmission to the propeller. Also on show will be a static model of a tanker with a nuclear propulsion unit. Both models will be purely hypothetical.

'No-break' alternator sets

Developed to meet the requirements of atomic power generation and the continuous process industries which demand a constant source of electricity to avoid temporary shut-down losses, these sets will be shown by Lister-Blackstone Group (stand D2). Stand-by power for

such installations must be capable of taking over duty without a break. To achieve this, an independent heavy flywheel is motored by an alternator when the mains source is available. In the event of failure or shut-down, the considerable momentum of the flywheel is sufficient not only to start the stand-by diesel engine but at the same time to drive the alternator and maintain output until the engine takes over duty. The demonstration set to be shown comprises a 3-cylinder normally aspirated four-stroke vertical diesel, developing 135 bhp at 600 rpm. Carried on the driven shaft is a 5ft 9in. flywheel weighing, with the shaft assembly, approximately 4 tons.

Nuclear graphite dust controllers

A range of dust control equipment for industry will be shown by Dallow Lambert & Co Ltd (stand Z3). It will include wet dusters, *Drytube* filters, cyclones, *Dustmaster* and *Drytex* unit dust collectors, suitable for foundry work, shipbuilding, welding and metal spraying. Illustrated is a *Drytube* installation with automatic shaking gear in course of erection, typical of the filters supplied for nuclear graphite control.

Transformer oil filter unit

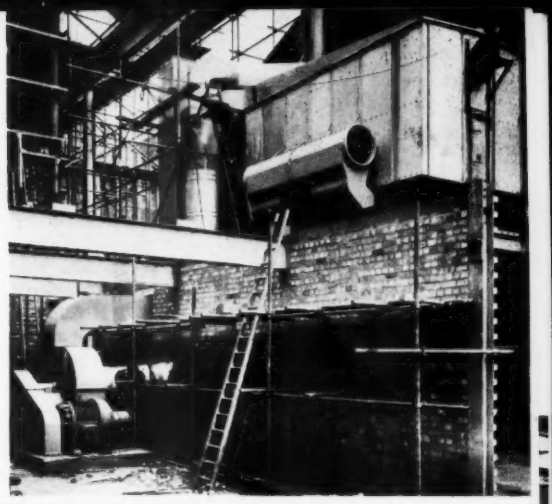
This trailer-mounted unit was supplied for use at Berkeley, Dounreay and Chapelcross by Stream-Line Filters Ltd (stand E8) and a large number are used as standard equipment by the CEA and electrical establishments throughout the world. The unit is coupled to the transformer with flexible pipes to form a closed circuit. The insulating oil is drawn from the transformer and returned to it continuously without change of level, the filter plant being full of oil, and the transformer need not be taken off load during circulation. Dirty oil is first heated electrically and then passed through the filter at a constant, predetermined rate. Filter comprises a number of packs, built up of specially prepared paper and maintained under pressure by spring loading. After filtration the oil is dried and de-aerated under vacuum, and a rotary pump extracts the clean, dry oil and returns it to the transformer. Plants with outputs of up to 450 gpm are available.

Bellows sealed stop valves

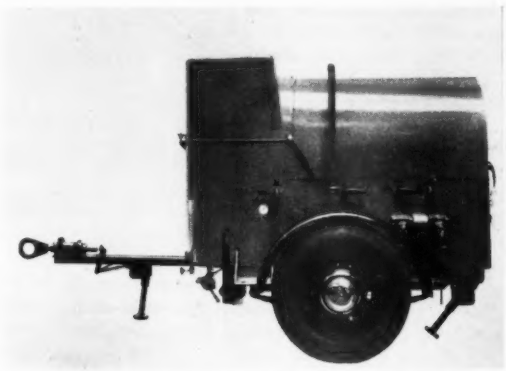
Specially constructed for service in nuclear power stations, examples of these valves will be shown by Dewrance & Co Ltd (stand H8). They are supplied for the control of carbon dioxide and other fluids for pressures up to 250 psi. Bodies are in carbon or alloy steel stampings with seats directly deposited with *Endewrance*, a hard faced non-corrodible alloy, capable of withstanding severe service conditions. Valvehead is of stainless steel and is amply guided so that the valve forms a true seating. Special feature of this design is that bellows are fitted above the valvehead to prevent leakage of fluid between the spindle and the gland. The cover is also tip welded to ensure that there is no leakage at the cover joint. This design is available in sizes up to 10in., the larger sizes having bodies fabricated from steel tubing.

Ultrasonic immersion testing

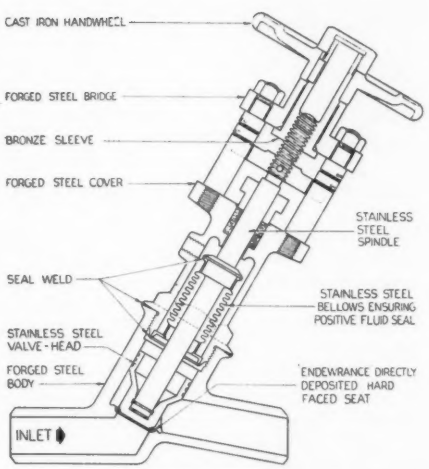
This new equipment will be shown by Solus Schall Ltd (stand V7). In order to overcome the disadvantages sometimes involved in manual operation of probes for ultrasonic testing, this automatic technique has been adopted, in which the specimen, immersed in water, is scanned by a mechanically propelled probe. The method also has the advantage that there is no wear and tear on the probe which has a very delicate surface. The installation comprises an ultrasonic echo sounding apparatus, the lithium sulphate probes which take the place of the ordinary quartz or barium titanate pattern as they have greater sensitivity and resolving power, the probe manipulator,



DALLOW LAMBERT—nuclear graphite dust collector

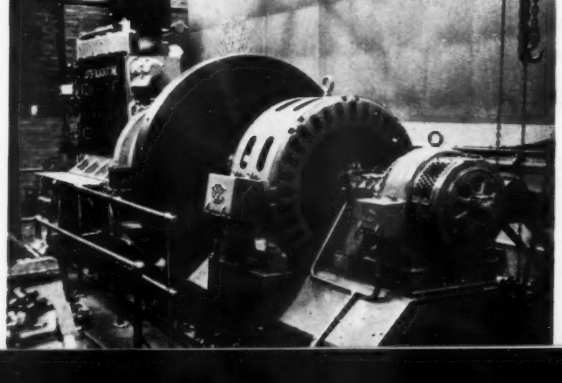


STREAM-LINE FILTERS—transformer oil filter



DEWRANCE—bellows sealed stop valve

LISTER—' no-break ' alternator



motor driven scanning device, control desk and tank, which can be made to any dimensions and can be equipped with a turntable for the examination of round specimens.

Also on show will be two types of isotope containers for gamma radiography consisting of a hollow phosphor bronze casting mounted on a stirrup and base plate. In one type the bronze shell is filled with lead, and in the other with a block of tungsten 'heavy-alloy'; total weights are 30 and 44 lb respectively. A protractor is fitted to the stirrup to indicate the elevation of the gamma-ray beam.

Other products on the stand will include a new roughness gauge, miniature ultrasonic equipment, magnetic testing equipment and complete X-ray tubeheads for the *Eresco* portable X-ray unit.

Insulation at Calder

The Darlington Insulation Co Ltd (stand L5), the contractors which supplied the insulation for Calder Hall, will illustrate their work with photographs. On the same stand, the Chemical and Insulating Co Ltd, also a member of the Darlington group, will show examples of their insulating and finishing materials, including 85% magnesia, suitable for temperatures up to 650°F, metadextramite and dextramite, for temperatures up to 1200°F and 2000°F. Materials are made in preformed sections, in slabs and moulds, and in powder form for plastic application, and samples of the various forms will be displayed, together with samples of finishing materials for heat insulation.

Another member of the group, British Refrasil Co Ltd will show examples of *Refrasil*, the light-weight silica insulator in the form of very fine fibres, capable of withstanding continuous temperatures of 1000°C. Available in the form of batt cloth, tape, bulk fibre, sleeving, cord and yarn, it is adaptable to blanket construction, making it suitable for insulation of electric furnaces, thermocouple leads etc.

Package air preheater

Among the James Howden & Co Ltd (stand E9) exhibits will be a package air preheater suitable for auxiliary boilers and smaller industrial plants and power stations. A model of the latest type of Howden-Ljungström air preheater of the rotary regenerative type will be exhibited in the form of a scale model. A 200 mm compressor will be shown with casing sectioned to display the rotors and diagrams and photographs of the Howden electro-precipitator will also be displayed.

Berkeley model

The sectionalized model of No 1 reactor and heat exchangers for Berkeley to be shown by John Thompson Ltd (stand F4) will include one illuminated circuit indicating the course of the coolant from reactor to heat exchanger. The firm's part in the construction of the Dounreay Fast Reactor will also be illustrated.

Oxygen cutter for Bradwell pressure vessel

A new oxygen cutting machine being built by Hancock & Co (Engineers) Ltd (stand X6) to cut the control apertures in the Bradwell pressure vessel will be illustrated by an artist's impression. The machine will cut non-radial holes to accommodate the vertical control rods to close tolerances through the 3in. steel hemisphere, using a double bevel and nose preparation for welding. It is actuated by a variable speed motor through worm and belt drive operating a connecting rod, which carries an oxygen burner on an extended arm. A separate linkage controls the angle to which the cutter can be set. Control is provided to allow a differential bevel angle to be cut so that the amount of weld metal to be deposited can be made uniform round the hole. Raising and lowering of the burner is carried out automatically to follow the spherical surface during cutting. Mounted on a carriage, the machine is lowered into the cutting position by three screws which are also used for levelling.

The machine and the gantry are carried on a two-railed gantry which pivots about a pintle welded to the top centre of the sphere. Outer end of the gantry is fitted with wheels running on a rail welded to the sphere. Two operators are normally required to work the machine.

Submersible pumpset

The main feature of the Harland Engineering Co Ltd (stand DD6) centres around the Ulectriglide submersible pumpset. Use of these in various industries will be described—in a recent installation supplied to the National Coal Board, the rating was 250 hp at 1460 rpm with 3000/3300 volt supply, pumping 600/800 gpm against 835/650ft head. Reference will also be made to Harland's high tension submersible pumpsets which have now completed the prototype stage. Illustrations, models and specimens from the range of the company's products, including water turbines, alternators, all types of centrifugal pumps, rotovalves and industrial nozzles, will also be displayed.

Liquid relief valves

Shown for the first time by Megator Pumps & Compressors Ltd (stand C9), these valves, made of high quality bronze with cadmium-plated carbon steel valve springs, are claimed to have a number of unusual features. Also being shown for the first time will be a new version of the well known mobile industrial pump with the pump set mounted on a robust four-wheeled metal trolley, with welded tubular handle and bracing struts. Standard range covers capacities between 8 and 50 gpm, but greater capacities are available to order. The set can be adapted, if required, to carry a length of flexible hose.

Pump for radioactive liquors

British LaBour Pump Co Ltd (Inner 23, Gallery, National Hall) will show their type BG pump which has been supplied in large numbers to AWRE. Absence of mechanical seal or gland packing has made the design particularly suitable for handling radioactive liquors. It is manufactured in a wide range of corrosive materials including stainless steel, the LaBour alloy R55 and other high nickel alloys. The pump is vertically mounted and self-priming is achieved without foot valves or other mechanical aids and can consequently be sited away from the source of supply. Wear is minimized by the inclusion of only one moving part.

Canned pumps for 'Dreadnought'

G. & J. Weir Ltd will be showing the hermetically sealed pump developed in close collaboration with the English Electric Co Ltd who supplied the motor. It is specially designed to circulate liquids at high temperatures and pressures in nuclear power circuits where leaktight pumps are essential. Materials used throughout the pump have been selected to meet the unusual conditions. These pumps are to be supplied for the pressurized water circuit of the land-based reactor prototype of the nuclear submarine HMS *Dreadnought*.

Industrial radiography equipment

Principal exhibit on the stand of Gamma-Rays Ltd (stand Z4) will be the model ASS/54 container for 20 curies of cobalt-60. It is suitable for heavy industrial work such as the examination of heavy castings in practicable exposure times—6 in. steel in 30 minutes. Electrically operated by a remote control panel, the machine makes its own exposures by pre-set timing and will close 'safe'

if the door of the radiography room is opened during the exposure. Suitably modified, the unit can be used as a radiotherapy head taking 2000 curies of caesium-137.

Among a variety of other isotope containers, the one illustrated is model ASS/51 operating container for 600 millicuries of cobalt-60 or high strength iridium. Shown with remote control source-protruder attachment, it is for panoramic examination, total weight is 84 lb.

On show for the first time will be an iridium decay clock to record decay from 10c to 100 mc. Measuring 11 in. by 10 in. by 9 in., it has three independent dials and provision for extension units.

Control rod actuator

Metropolitan-Vickers Electrical Co Ltd (stand G13) will show an actuating mechanism for combined control and shut-off rods of a thermal reactor. 480 of these are being supplied for Calder A and B, and Chapelcross. Mechanism is designed to provide a slow 'out' and two faster 'in' speeds and to hold the rod in any required position. It is also capable of giving a controlled shut-off independent of the electricity supply. It consists of a synchronous control torque motor, fed from a variable frequency supply, driving through a 20:1 reduction gear on to a cable reel. Speed of the rods to the shut-off condition is controlled by a permanent magnet eddy current brake. Rod position indication is given by a geared magslip transmitter. Entire mechanism is dry-lubricated with molybdenum disulphide.

Pump for activated sludge

The industrial Pump Section of Mono Pumps Ltd (Inner 31, Gallery, Grand Hall) will show their type H stainless steel pump used for handling activated sludge and slurries for uranium extraction. At uranium reduction plants it is used for pumping reagents to the flotation cells for separation and also handles the slurry obtained after flotation. Lime slurry is added to the flow to obtain the correct pH value and Mono Pumps are used for handling this and the animal glue used extensively throughout uranium plants to agglomerate particles which have to be separated from the slurry. As it leaves the plant, the final product is in the form of a thick yellow/orange paste and the type H pump is used to extract the precipitate during the final stage of processing.

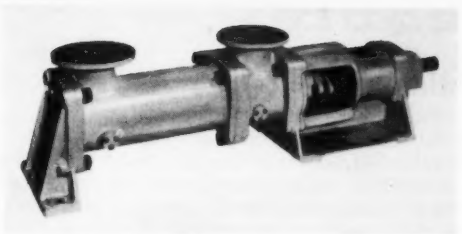
Glass for shielding

Glass as a protective material is the theme of Pilkington Bros Ltd (stand F9). Central feature will be three types of viewing windows giving protection against various radiations.

One window, measuring 3ft 6in. by 2ft 6in. and comprising 36 one-inch thick stabilized special plate glasses will illustrate one of the types of shield used in nuclear research. A demonstration of remote handling by mechanical manipulators will illustrate its use in hot cells. A slightly smaller window of the type used in hospitals to protect the medical staff operating a linear accelerator from dangerous radiation will also be displayed. Here the glass is one-inch clear white polished plate to the total of 30 plates.

A third type of window is in the form of a tank containing a special clear liquid and having at each end one-inch polished plate glass, the inner glass being stabilized against darkening and the outer, observer's end, being unstabilized.

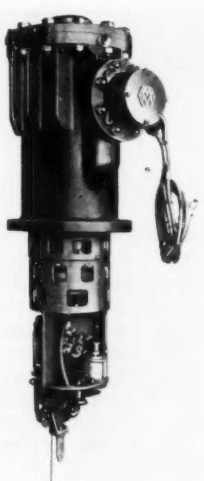
Other types of glass to be shown give protection against intense heat, pressure, dangerous liquids or flying particles, and moving machinery. Also displayed will be a string of toughened glass high voltage insulators of which it is claimed more than six million are in use in most countries in the world.



MONO PUMPS—pump for activated sludge

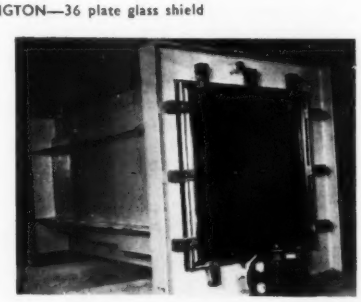
GAMMA-RAYS—container for cobalt-6

WEIR/ENGLISH ELECTRIC—canned pump



METROPOLITAN-VICKERS—control rod actuator

PILKINGTON—36 plate glass shield



EQUIPMENT

Miniature direct-acting pumping can be in P.T.F.E.

Driven by a pneumatic piston motor of novel and simple design, the Neumo direct-acting pump has been developed for handling liquids in the chemical and process industries and should find ready application in atomic energy plants where maintenance considerations may mean complete replacement of the unit. In its standard form the pump consists of a cast-iron cylinder with detachable cylinder heads and valve chests. The pump is double acting and the inlet and delivery valves are identical thus permitting interchange of the two valve chests to suit particular layouts. The valves are self-contained in their own cages and consist of hardened steel disks on soft seats. The plunger is of the double cap type and normal materials are of moulded leather or p.t.f.e. Glands are of the chevron type and are in rubber or p.t.f.e. These pumps have been made in stainless steel and in non-ferrous metals with suitable liners. A more recent development is a complete unit in p.t.f.e. for handling certain corrosive liquids.

The standard Neumo pump weighs only 13 lb 2 oz

The air motor is directly coupled to the pump plunger, the two units being rigidly connected. Inlet to and exhaust from the power cylinder is controlled by a fully-free piston valve. By arranging cushioning air at the stroke extremities the pump is self-starting and has no dead positions. The power piston is solid steel, hardened and ground to fine limits and running in a honed cylinder. The piston valve is of similar construction and has nylon piston rings. Lubrication is claimed to be quite unnecessary.

Motors and pumps can be coupled in various sizes to suit requirements. The standard motor consumes between 2½ and 3½ cfm of air at 65 to 80 psi. Deliveries vary of course according to the viscosity, discharge and head. For example, at 80 psi air pressure, 100 gph of paraffin can be delivered against 35 psi. If the air pressure is raised to 100 psi, 45 gph can be delivered against 70 psi.

Applications already reported include: oils (including suspensions); paints, solvents, acids, liquid foods. The p.t.f.e. model is claimed to be able to handle virtually any liquid up to 200°C.

Kingsbourne Products Ltd,
216 South Coast Road,
Peacehaven, Sussex

Examining radioactive metallurgical specimens

A remote control metallurgical microscope developed for the AEA Industrial Group, Risley, was demonstrated in London recently. The result of several years' development work initiated at Harwell, the microscope is basically the Reichert universal camera microscope, modified by Shandon Scientific. All operations including placing the specimen, focusing, objective changing, stage movement and rotation, changing of light sources and filters are carried out remotely from behind shielding walls. Some of these, such as objective changing are carried out by mechanical means; others are done by miniature electrical motors controlled from a console outside the shield.

The complete equipment comprises four main groups: the inverted microscope, complete in itself; light sources, of which there are several available; optical equipment such as objectives and eyepieces; photomicrography and television equipment on a 1-metre optical bench.

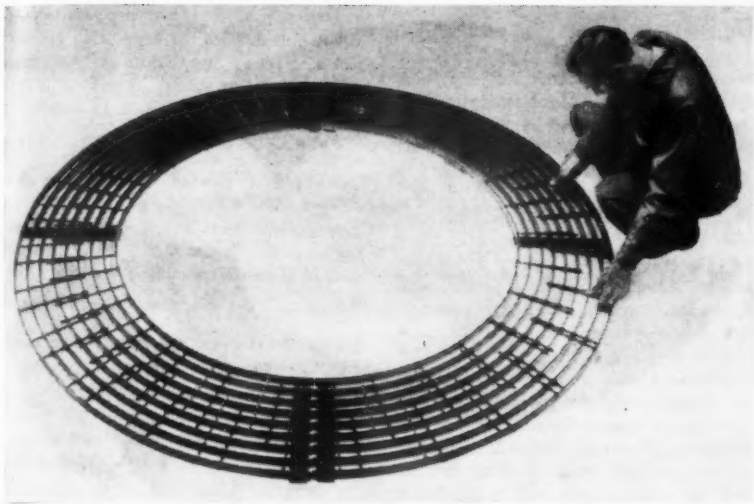
Shandon Scientific Co Ltd,
6 Cromwell Place, London, SW7

Transistor survey meter has glass fibre case

Although designed for geological surveying and prospecting for radioactive ores, the Ericsson survey meter, type 125, has many applications as a portable gamma radiation monitor. Overall dimensions are 1¼ in. by 3½ in. by 7¼ in. and total weight, including batteries, is 1½ lb. Visual indication is by a moving coil meter and audible indication by a lightweight hearing aid headset. The all-transistor circuit is powered by three 1½V hearing aid cells housed in a special compartment by a bulkhead. With an average daily use of eight hours, the battery life is approximately fourteen days. An external battery pack can be supplied for underground or night surveying. Unit can be clipped on to the pocket or belt and when in use the batteries in the instrument are by-passed. Batteries for this unit are internationally available and give the instrument a life over 500 hours.

Ranges covered are 0-0·5 and 0-5 mR/h. Ruggedly constructed of fibreglass, the instrument will operate at temperatures from −30°C to +60°C. Instrument components are contained in a hermetically sealed compartment provided with a desiccator.

Ericsson Telephones Ltd,
Beeston, Nottingham



Open flooring and walkways

Flowforge open steel and aluminium flooring by Fisher & Ludlow is electrically forge-welded and has a high strength to weight ratio with maximum light passing and ventilation capacity. It is produced in stock panels 20 ft by 3 ft and these, together with stair and ladder treads, are available in various sizes. A recent development demonstrating its versatility is a contract for circular panels measuring 6 ft 6 in. to the outside edge. These panels have been produced to form circular walkways on tank cars, providing a platform which is strong but light, safe under all weather conditions, and requires no maintenance. The old method of burning a square panel to form a circular shape with all its adherent wastages has been dispensed with. The circular panel is now fabricated in two half units from serrated edge steel rings, spaced and held in position by forge-welded twisted bars spanning six serrated rings in lattice pattern, construction being carried out on top and bottom faces.

Fisher & Ludlow Ltd,
Material Handling Division,
Bordesley Works, Birmingham, 12

Health physics ratemeter

The Burndept ratemeter type BN110 has been primarily designed as a health physics instrument for measuring the radiation from contaminated surfaces and apparatus, and for personnel monitoring. Two probes are used for the detection of radiation. The beta gamma probe incorporates a geiger tube and a shutter to exclude beta particles when it is required to measure gamma only. The alpha probe has a 16 sq. in. zinc sulphide screen and uses an 11 stage photomultiplier.

The ratemeter circuit, which includes a wide band amplifier and discriminator, provides aural and visual indication of count rate. Positive output of at least 5 V is available for scaler operation. For accurate determination of low count rates an electro-mechanical register is included which will count individual pulses up to 10 per second. The register is resettable, eliminating the calculation necessary with the usual continuous count type. A variable EHT supply for the probes has been built in, incorporating an output suitable for the operation of a halogen quenched geiger tube.

The ratemeter complete with probes is easily decontaminated, self-contained radiation monitor, readily transportable and requiring only an a.c. mains supply to begin operation.

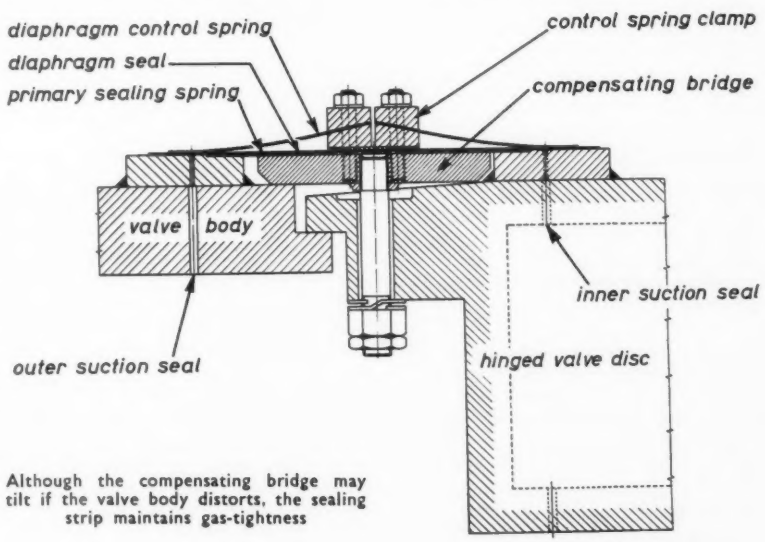
Burndept Ltd, Erith, Kent

Novel sealing feature of proposed reactor gas valves

A vital part of a gas-cooled nuclear power plant is the main valve in the gas circuits, by means of which the heat exchangers can be isolated in turn for maintenance or repairs. These units are not required for control purposes and are always fully open or shut but it is important that gas leakage in the shut position is reduced to vanishing point so that access can be gained to the heat exchanger without hazard from radioactive gas.

Pressures (about 150 psi) and temperatures (up to 700-800°F) are not high by modern power station standards but in the new stations the gas ducts are 5 ft in diameter and so the load on the valve is very considerable. With normal cast steel construction, distortions due to high loads or misalignment and traces of dust can lead to improper seating and subsequent leakage. In an attempt to overcome these difficulties, an entirely new approach to the problem is being offered in the shape of the *Metro-Flex* high pressure valve. Designed by Metropolitan Combustion Engineering Ltd, the valve relies for its sealing effect on the principle of a thin flexible steel strip bearing on a flat surface and is a development of flue dampers and isolators supplied by this firm for many years for coal and oil fired boilers.

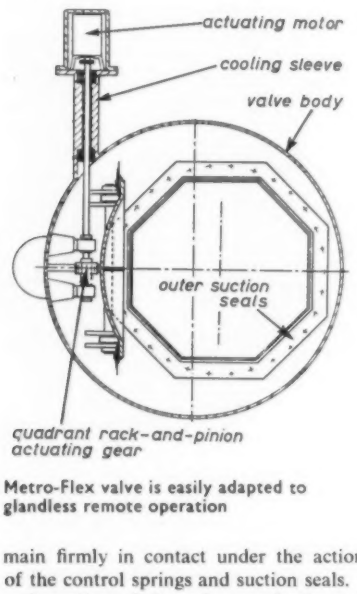
The *Metro-Flex* system accepts the fact that there will be distortion and aims to accommodate this by a flexible sealing system. The valve is a pivoted disk type unit of octagonal section with very wide



Although the compensating bridge may tilt if the valve body distorts, the sealing strip maintains gas-tightness

clearances of the valve disk in its seating: this makes fouling or jamming virtually impossible. Along the edges of the octagon are loosely-mounted compensating bridges which connect the valve body with the disk in the closed position. Sealing is accomplished by special austenitic steel sheet about 0·06 in. thick extending right over the compensating bridge and lying flat on the valve body and disk. This strip is held firmly pressed on the flat surfaces by control springs and a closed gas-tight seal is assured by holes bored through the valve body and disk from the low pressure side terminating under the sealing strip.

If distortion of the valve occurs, the compensating bridge merely rocks slightly on its seating and the sealing strips remain firmly in contact under the action of the control springs and suction seals.



Metro-Flex valve is easily adapted to glandless remote operation

Operation of the valve can be by any convenient method but it is claimed to lend itself to completely glandless operation by having the electric motor entirely within the gas pressure.

Metropolitan Combustion Engineering Ltd, 47 Whitechapel High St, London, E1

Equipment summary

PRE-FLUSH GAS FLOW COUNTER, model 21, is low background 3-position windowless counter for geiger or proportional region. Counts low activity betas, alphas —separately or together. *Atomlab Inc, 489 Fifth Avenue, New York 17, NY*

QUARTZ LINE HEIGHT ANALYSER—a 100-line instrument for rapid accumulation of data on amplitude distribution of electrical pulses arriving at random intervals. For recording spectrum data of isotopes, rapid routine chemical analysis. *Nucleonic Corporation of America, 196 Degraw Street, Brooklyn 31, NY*

Dounreay lab flooring

Protection of construction materials against radioactive contamination at Dounreay was provided by Acalor (1948) Ltd. The firm was invited to construct flooring, channels and line large tanks to a specification defined by the Authority. The form of construction provided for a 0·010 in. polythene membrane. Main flooring consisted of bricks bedded in portland cement mortar and jointed with plasticized sulphur and the channel blocks were bedded and jointed with potassium silicate cement. A similar specification was used for the lining of the effluent tanks. Polythene foil is impervious to the conditions and provides a reliable second line of defence, while portland cement, as a bedding mortar, provides a warning signal. A weakness lies in the lack of adhesion between the brickwork and the membrane—the floor is floating and held in position by its own mass.

Acalor have a research department organized to develop new materials to withstand high temperatures, erosion and attrition in addition to severe chemical and active conditions.

Materials which have proved equal to these conditions include dense acid resisting bricks bedded and jointed in mineral filled furane and phenolic cements. Very high density tiles and epoxy resin cements provide a barrier to both a wide range of chemicals and a high degree of radiation. Among plastic materials, for some purposes, reinforced polyesters have proved extremely resistant. On the other hand, many plastic materials have displayed evidence of attack. Nylon and polythene tend to become brittle, acetate to become black and to soften, and some polyesters decrease in tensile and impact strength. Generally speaking, rubber-based materials are unsatisfactory.

Acalor (1948) Ltd, Kelvin Way, Crawley, Sussex

GAMMA SENSITIVE SCINTILLATION DETECTORS—two new directional detectors, models DS5-1 and DS5-1P, particularly suitable for medical use, also research and industrial applications where directional characteristics are important. *Nuclear-Chicago Corporation, 223 West Eric Street, Chicago 10, Ill*

SYNCHRO CONTROL TRANSFORMER type 15CT4a has received type approval from Ministry of Supply; used with synchro control transmitters in closed-cycle servo systems. *Ketay Ltd, Eddes House, Eastern Avenue West, Romford, Essex*

TRANSISTOR TEST SET TYPE 74163-A—a small portable set for measuring current gain of p-n-p transistors in common emitter configuration. *Standard Telephones and Cables Ltd, Connaught House, Aldwych, London, WC2*

UNIFLOW UNIT HEATER—incorporates new body styling; heating coil is claimed to give greater heat output than conventional coil of same size. *F. H. Biddle Ltd, 16 Upper Grosvenor Street, London, W1*

DIFFERENTIAL PRESSURE TRANSDUCER type ER 125—converts differential pressures into direct current signal suitable for remote indication or as 'measured value' signal for electronic process controller. *Evershed and Vignoles Ltd, Acton Lane Works, Chiswick, London, W4*

FLEXIBLE METALLIC CONNECTORS—seamless bronze or stainless steel flexible bellows brazed to flanged or screwed end fittings; suitable for vacuum or low pressure applications. *Precision Heating Ltd 142a Canbury Park Road, Kingston-on-Thames, Surrey*

GRID CONTROLLED INDUCTION HEATERS, for 9, 15 and 25kW—designed to be independent of mains supply variations and giving constant power output over the full 20:1 output range. *Radio Heaters Ltd, Eastheath Avenue, Wokingham, Berks*

SCINTILLATION WELL COUNTER, model DS5-5, is for high efficiency measurement of gamma emitting liquid or solid radioactive samples down to 10^{-5} microcuries. Overall sensitivity is approximately 50%. *Nuclear-Chicago Corporation, 223 West Eric Street, Chicago 10, Ill*

WINDOWLESS SCANNER, model F, designed for scanning of two-dimensional paper chromatograms tagged with low energy beta-emitting isotopes. *Forro Scientific Co, 833 Lincoln Street, Evanston, Ill*

ULTRASONIC GENERATOR giving 38 kc/s frequency has sufficient power for transducers with a total area of 30–40 sq. in. Units are primarily designed for cleaning with organic solvents, detergents, alkaline solutions and mild acids, but can also be used for other ultrasonic applications. *Dawe Instruments Ltd, 99 Uxbridge Road, London, W5*

DIRECT-READING FLUORIMETER, model 27, gives quick results by comparison of sample with standard. Several readings a minute can be done with discrimination of 2 parts in ten thousand million. Applications include metallurgical work on aluminium and boron. *Electronic Instruments Ltd, Lower Mortlake Road, Richmond, Surrey.*

Solid homogeneous reactors are news. How do possible gases compare thermodynamically?

Coolant choice for the v.h.t. reactor

PETER FORTESCUE, PhD, WhSc

Reactor Division, Harwell

IN CONSIDERING gas-cooled reactors for high temperature operations, possibly in conjunction with forms of gas turbine plant, the question of working gas at once arises. Compatibility, irradiation decomposition, and mass transfer will no doubt severely restrict ultimate choice, and adequate information on these questions calls for further experiment, but let us first sort out just what properties we are looking for, so that the field may be at least restricted to good starters.

Criteria

So far as heat transfer and thermodynamic considerations are concerned, there is no one magic number which expresses the relative merit of all working fluids. For instance, the criterion for minimizing pumping power is different from that controlling plant size, or complexity (number of stages of compressors or turbines), and matters are influenced by whether some surface temperature, or gas temperature, or some stress consideration are taken as design limitations.

However, it is possible to tidy up this situation very considerably by a little general preliminary analysis, from which the influence of gas properties on some selected design features can be tabulated.

We shall be mainly concerned with solid homogeneous cored reactors, partly because this construction offers great promise of securing high power density, and partly because this field lends itself to wide generalization.

We are not, for instance, tied to the use of particular channel pitching by nuclear considerations, which may be regarded as being influenced only by the total coolant voidage fraction. A further point is that in the homogeneous case, such large primary surface areas are available that the use of secondary surface is unnecessary, which greatly extends the generality of the results.

Pumping power

It can be shown that the cooling performance of a homogeneous core, pierced by smooth cooling channels of any uniform section, is given by:

$$\left(\frac{H}{A\,\Delta\,T}\right)^2 = x^2 c_p{}^3 \rho^2 \Delta t_s \left(\frac{h_p}{H}\right) \qquad (1)$$

where:

$\left(\frac{H}{A\,\Delta\,T}\right)$	is the heat produced, per unit core frontal area, per degree coolant temperature rise
x	is the total coolant passage voidage fraction
$\left(\frac{h_p}{H}\right)$	is the pumping power expended, expressed as a fraction of the heat generated
Δt_s	is the permitted mean temperature difference between the core surface and the coolant
c_p and ρ	are the specific heat and density of the coolant

It will be seen that, for given temperature limitations, pumping power required to produce a given heat, from a core of fixed overall size and coolant voidage space, is proportioned to $(c_p{}^{-3}\rho^{-2})$, or, if ambient pressure is also fixed, to $(C_M{}^{-3}M)$, where M is the molecular weight, and C_M is the molar specific heat of the coolant. Alternatively, if fractional pumping power (h_p/H) is specified, then heat output obtainable will vary as $(C_M{}^{3/2}M^{-\frac{1}{2}})$, other design restrictions being the same.

The size and number of the individual coolant passages do not enter into the above relation explicitly as they are dependent variables, fixed by the conditions specified above. It must be remembered, however, that comparison of different coolants on the criterion mentioned, implies that the core passages are in each case adjusted (according to the relations given in the appendix) to suit the particular gas used, if both surface and coolant temperature are to remain fixed.

Equation (1) leads to some interesting conclusions about the magnitude of the pumping power it is desirable to expend in a given case. Consider a reactor of heat output H, operating with a power plant of efficiency η_t, the ideal pumping power (h_p) being supplied by a compressor, of efficiency η_c, driven by the main plant. Since all the power expended in compression will appear as heat in the reactor circuit, we will have a net power produced by the system of:

$$H_N = \eta_t \left(H + \frac{h_p}{\eta_c}\right) - \frac{h_p}{\eta_c}$$

or, (2)

$$H_N = \eta_t H \left[1 - \frac{h_p}{H}\left(\frac{1-\eta_t}{\eta_c\,\eta_t}\right)\right]$$

But, from (1), at given coolant and surface temperatures,

$H = C\left(\frac{h_p}{H}\right)^{\frac{1}{2}}$ where C is a constant.

So, to maximize the net output within given operating temperature limits,

$$\left(\frac{h_p}{H}\right)^{\frac{1}{2}}\left[1 - \frac{h_p}{H}\left(\frac{1-\eta_t}{\eta_c\,\eta_t}\right)\right]$$

must be a maximum.

Differentiating and equating to zero, shows this will occur when:

$$\left(\frac{h_p}{H}\right) = \frac{\eta_c\,\eta_t}{3\,(1-\eta_t)} \qquad (3)$$

when this value of pumping power is used, the net output would thus be, from (3) and (2),

$$H_{N\,(opt)} = \frac{2}{3}\eta_t H \qquad (4)$$

From this it will be seen that the value of fractional pumping

power (h_p/H) giving maximum net output, is independent of the nature of the coolant and, furthermore, extraction of the utmost useful power always involves expending one-third of the output of the station on pumping.

Such a mode of operation would of course entail a sacrifice of one-third of the possible plant efficiency and, in practice, a compromise has to be struck between the conflicting requirements of output and efficiency.

As nuclear power plant is generally characterized by relatively high capital cost and low fuel cost, this compromise will normally be heavily weighted towards keeping up high output.

For these reasons, the heat output obtainable for a given fractional pumping power is a more directly interesting measure of a coolant's capability than is its effect on pumping power at a given output. Also, since it will thus pay to employ substantial pumping powers, even with the best coolant, the question of required circulator size is of importance.

Circulator stages

When using the lighter gases, He, H_2 or N_2 as coolants, stress considerations generally dictate that several circulator stages are required to induce the economically desirable cooling flow. It is therefore of interest to see how gas properties influence this requirement. Stress, rather than Mach number, has been taken as limiting stage performance, because in practice the sort of peripheral speeds consistent with long operating life, as well below the sonic speeds of these coolants. High Mach numbers are in any case not required, for only low pressure ratios are ever involved in reactor cooling.

As is well known, geometrically similar designs of compressor stages, operating at the same stress (and therefore the same peripheral velocity), produce a stage temperature rise inversely proportional to specific heat, and this is the only gas property involved. This is true of both axial and centrifugal types. If the compression ratio is small, this implies that the pressure rise produced is proportional to the gas density only.

From the definition of pumping power, we have $h_p = \frac{W\Delta P}{\rho}$ and from the heat balance, we have $W = \frac{H}{c_p \Delta T}$, combining which, we get

$$\frac{h_p}{H} = \frac{\Delta P}{c_p \Delta T \rho} \qquad (5)$$

This shows that if the fractional pumping power $\frac{h_p}{H}$ is to be kept constant with different gases, the required pressure drop ΔP must vary as $(c_p\rho)$, if we stick to the same reactor temperature rise. The corresponding number of stages needed will therefore vary as $c_p\rho/\rho$, i.e. as c_p, or as $C_M M^{-1}$.

Substituting (5) in (1), gives:

$$\left(\frac{H}{A\,\Delta\,T}\right)^2 = x^2 c_p^2 \rho \left(\frac{\Delta t_s}{\Delta T}\right) \Delta P \qquad (5a)$$

From this, it follows that making a change of coolant at constant heat output, leads, other things being the same, to a pressure drop requirement proportional to $c_p^{-2}\rho^{-1}$, so the number of stages wanted would vary as $(c_p\rho)^{-2}$, or, at a given pressure to C_M^{-2}.

Circulator volume

The circulator volume required is an important factor, because of its influence on cost, and also on accessibility. Again considering only geometrically similar stage designs, the compressor bulk will be proportional to the product of volume flow, and number of stages, the throughput velocity being fixed because the blade, or peripheral velocities are fixed by stress.

At constant reactor heat output, the volume flow required (at given temperatures and pressures) will be proportional to C_M^{-1}, and this condition, we have seen, calls for a number of stages proportional to C_M^{-2}, so the compressor volume will be proportional to C_M^{-3}.

In the constant fractional pumping power case, the volume flow which is proportional to $\frac{H}{\rho c_p}$ for a given temperature rise, would, by (1), vary as $c_p^{\frac{1}{2}}$, at a given reactor surface temperature. Since, we have seen the number of stages wanted varies as c_p for these conditions, it follows that the circulator volume would vary as $c_p^{3/2}$, or $C_M^{3/2}M^{-3/2}$.

Duct volumes

It is normal practice to allocate some definite fraction of the total circuit ΔP to duct losses. The pressure loss in a duct of diameter d_D, and length l_D will be

$$\frac{2 f_D \rho V_D^2 l_D}{d_D}$$

which is equal to

$$\frac{8 f_D H^2 l_D}{\pi c_p^2 \Delta T^2 \rho d_D^5}$$

where f_D is the effective duct friction factor.

But, from (5a), the reactor pressure drop will be given by:

$$\Delta P = \frac{H^2}{A^2 \Delta T x^2 c_p^2 \rho \Delta t_s}$$

So, if we are to keep duct losses at a constant fraction of the reactor core pressure drop, we must keep $\frac{f_D A^2 x^2 \Delta t_s}{\Delta T d_D^5}$ constant.

The required duct diameter is therefore proportional to

$$\left(\frac{A^2 x^2 \Delta t_s f_D}{\Delta T}\right)^{1/5}$$

So, apart from very second order influences of Reynolds number on f_D, we can say that cores of given voidage, designed to common surface and coolant temperature specifications, all want the same duct diameter—irrespective of the coolant, or the operating power.

Heat exchangers

Where a gas-cooled reactor is used for steam raising, the bulk of the required heat exchanger is mainly determined by the gas side conditions, for not only are liquid and boiling heat transfer values very high, but also generally much higher pressures would be used on the steam side, reducing the volume of the latter.

In these circumstances, the general analysis of reactor core cooling could be considered as equally applicable to the performance of the heat exchanger, assuming that the latter employed no secondary surface. For a given distribution of component losses, this would mean that the required proportions between the dimensions of the reactor, the ducting and the heat exchanger would be unaffected by coolant choice. As in the case of the core, different gases would require different tube pitching, but overall shape, size and voidage would not be affected.

Power gas turbines

We have so far considered only components associated with an isolated primary circuit. Where a gas turbine producing external power is involved in the circuit, quite different

considerations prevail. In such a system, need for preserving reasonable efficiency would enforce the employment of reactor pressure losses small compared with the pressure differences across the turbine and compressor, the main consideration in working fluid choice then being left with its influence on turbine size.

For the same thermal efficiency, the temperature rise across the compressors (and turbine temperature drops) must be kept constant. Since the temperature rise per stage is proportional to c_p^{-1}, the number of stages wanted is proportional to c_p, or to $C_M M^{-1}$.

The gas volume flow rate would vary as C_M^{-1} for the same power and therefore the volume of the plant (product of number of stages and volume flow) would vary as $c_p C_M^{-1}$, that is to M^{-1}.

Maximum surface temperatures

We have so far employed the term Δt_s, the mean value of the surface-to-coolant temperature difference, to specify surface temperatures. In practice, heat release is not uniform throughout the core, and are usually interested more in maximum than in mean temperature.

The term Δt_s is however still of use to us, for the required maximum temperature can be computed from it, once the heat flux distribution is known.

Thus, for a sinsoidal axial heat flux distribution, it can be shown quite straightforwardly that:

$$\frac{T_{max} - T_0}{\Delta T} = \tfrac{1}{2}\left\{1 + \frac{\sqrt{1 + (\pi\phi\Delta t_s/\Delta T)^2}}{\mathrm{Sin}\,\frac{\pi}{2}\phi}\right\}$$

where T_{max} is the maximum surface temperature
ΔT is the coolant temperature rise in the highest flux channel
ϕ is the ratio of the core length to its extrapolated length between points of zero flux.

Density changes

We have so far treated density as though it were constant in the core. In practice quite substantial density changes are encountered due to temperature change. As a first approximation we may treat ρ as the mean density in the core, but in this case the pumping powers computed would be too high, for circulators would normally be situated at the entry position, where the density would be higher. On the other hand, the approximation of constant density under-estimates the true reactor pressure drop, the more accurate expression being:

$$\Delta P = \frac{W^2}{(Ax)^2\rho_m}\left(\frac{2fl}{d_c} + \frac{\Delta T}{T_m} + \frac{\Delta P}{P_m}\right)$$

This is higher than the figure ignoring density change by the factor:

$$\left[1 + \frac{d_c}{2fl}\left(\frac{\Delta T}{T_m} + \frac{\Delta P}{P_m}\right)\right]$$

The above two effects thus operate in reverse directions, and in practice, for the sort of forecasting in which we are indulging here, it is quite sufficient to ignore these complications as we have done.

Heterogeneous cores

We have dealt so far only with the homogeneous cores. This construction lends itself to general analysis of the kind we have been doing, because we can treat the number and size of the cooling passages as a quantity which may be varied at will to suit the cooling, the only factor substantially influencing the nuclear side of the business being the total voidage. This has enabled us to draw realistic comparisons between coolants in projected designs having both surface *and* gas temperatures specified, for the changes in number and size of the coolant passages to meet these two conditions simultaneously can be made at constant total voidage, and therefore without influencing nuclear performance.

However, it is of interest to see to what extent the present conclusions are relevant also to developments of the Calder type core.

If finning is employed of the circumferential type, or if roughened surfaces are used, it has been shown,* that, for a given fin and channel geometry, the Stanton number S_t, based on fin root temperatures, is a function of $Re\,\frac{k}{k_m}$ The friction factor is independent of Re. Here k_m is the fin material conductivity.

Now we have:

$$Re = \frac{Wd_c}{Ax\mu} \quad \text{also} \quad \frac{\mu}{k} = \frac{P_r}{c_p} \;\&\; W = \frac{H}{c_p\Delta T}$$

we get therefore:

$$S_t = \psi\left(\frac{Hd_c}{Ax\Delta T P_r k_m}\right) \qquad (6)$$

Since P_r, the Prandtl number, is virtually constant for all gases, this means that if we take a given core design operating at a given total output, we will get a constant value of S_t, the Stanton number, for all gases, provided that we adjust the flow in each case to give a fixed value of coolant temperature rise. From (4) of the appendix, this implies that Δt_s, and therefore the mean fin root-to-coolant temperature difference is also determined.

In this case therefore, since we do not have to change core design at all to secure constant surface temperatures, when ΔT is fixed, we can take the conclusions about the effects of changing coolants at a constant power output as being applicable also to Calder type cores.

We cannot however generalize about the more interesting question of behaviour at fixed pumping power with varied power output, because the nature of the particular fin material and geometry adopted effects the form of the function (5) above.

It is important to observe that, if smooth primary surface only had been employed, the remarks on the heterogeneous case would *not* be true, for friction factor would not be virtually independent of Reynolds number, and also it would not be possible to hold both coolant temperature rise and surface temperature constant in the comparison without at the same time varying the lattice pitch.

General considerations

In considering reactors for power production, the designer generally has little room for manoeuvre in selecting inlet and outlet temperatures, for the demands of the power plant prescribe these fairly narrowly. Also with reactor gas inlet and outlet temperatures fixed, the relative merits of different coolants may be considered without introducing complexities concerned with repercussions on the design of the main power cycle. The maintenance of constant reactor temperature rise in the present comparisons is therefore considered realistic, and indeed essential to any particularly meaningful result.

Similarly, we have stipulated that the total core coolant voidage fraction shall not be varied in the comparisons, to avoid the confusion of bringing in changes in the nuclear performance. It is only fair also to keep constant core surface temperatures. To keep surface temperature, coolant temperatures, and core voidage constant simultaneously, requires that the number and size of the individual passages shall be chosen to suit the particular coolant used, but this is reasonable ,since we would not expect to change coolants

* Fortescue NUCLEAR POWER 2 13 p. 190 May 1957

after having fixed the core design. This freedom to alter coolant channel pitch without interfering with nuclear properties is of course possible only with effectively homogeneous cores.

Finally, the overall core size and shape, and the operating pressure are kept constant, so that changes in size and cost of pressure vessel are not involved. The fixing of core size and voidage also implies that the required primary circuit duct dimensions are unaffected by these comparisons, and, where steam raising is the object, heat exchanger bulk is also approximately unaffected.

Displaying results

The expressions developed are collected together systematically in Table I, which also gives numerical results for a number of particular coolants. The figures, which are based on gas properties at a mean temperature of 550°C, give the values of the more interesting parameters relative to the case of helium.

TABLE I—INFLUENCE OF GAS PROPERTIES

C_M = Molar sp heat (const. press.)
M = Molecular weight

Conditions held constant in all cases.
- Core external dimensions and total voidage
- Ambient pressure
- Inlet and outlet temperatures
- Surface temperatures

System	Additional Condition	Property Influenced	Property proportional to	Value with different gases, relative to Helium (at 550°C)								
				N_2	CO_2	H_2	A	CH_4	C_2H_6	C_6H_6	CF_4	Steam
ISOLATED PRIMARY CIRCUIT CIRCULATION	Constant heat output	Pumping power	$C_M^{-3}M$	1·63	·52	·14	9·6	·11	·04	·02	·24	·55
		Number of Circulator stages	C_M^{-2}	·38	·13	·43	·97	(·09)	(·03)	(·01)	(·049)	·25
		Circulator volume	C_M^{-3}	·23	·05	·29	·96	(·02)	(·005)	(·001)	(·011)	·10
	Constant ratio of pumping power to heat output	Total heat output	$C_M^{3/2}M^{-1/2}$	·78	1·39	2·64	·33	3·02	4·98	6·56	2·04	1·35
		No of circulator stages	$C_M M^{-1}$	·22	·23	3·1	·10	·83	·76	·51	·20	·47
		Circulator volume	$C_M^{3/2}M^{-2/3}$	·11	·13	5·3	·033	·95	·66	·45	·093	·32
POWER GAS TURBINE SET	Constant output and Plant Efficiency	No of stages	$C_M M^{-1}$	·23	·25	3·04	·10	·97	·87	·55	·21	·47
		Rotating plant volume	M^{-1}	·14	·09	2·0	·10	·25	·13	·051	·045	·22

NOTE: Bracketed figures hypothetical only as they would involve use of less than one stage
Gas Properties taken from 'Technical Data on Fuel' by H. M. Spiers

This table shows what happens when (*a*) the total heat output is fixed, or (*b*) when the fraction of the output devoted to pumping is fixed. It is important to note that the conclusions here reached under heading (*a*), are applicable also to Calder-type heterogeneous cores, but this extension is not possible in case (*b*). Apart from its wider generality, case (*a*) is of interest when internal thermal stress, or nuclear considerations limit the power density desirable. Where power is only limited by what we can economically get away from the heated surfaces, operation at constant fractional pumping power is the appropriate criterion, for the reasons already outlined. This case is more graphically illustrated by Fig 1, which shows at a glance how power output and circulation plant size are effected by the chosen coolant examples.

Some attractive possibilities

Insofar as Table I and Fig 1 are largely self explanatory, it will be sufficient here to draw attention to one or two outstanding points. The inert gases, being monatomic, share the same value of C_M, leaving low atomic weight the only criterion of excellence. This makes argon a particularly bad performer. Helium although far the best of the inert gases, is seen to be not particularly outstanding otherwise. For instance, with CO_2, we could get 40 pct more heat out, whilst employing only 13 pct of the blower bulk. Nitrogen although restricting power to some 80 pct of the helium value, would call for only about a tenth of the circulator bulk. Hydrogen, although capable of 2·64 times the output of helium would need 5·3 times the circulator bulk to do this. By contrast, if we could use CF_4 we could get nearly as much heat (2·04 times helium), but could get away with less than 10 pct of the helium compressor bulk. Steam has been included in the list in case anyone contemplated using nuclear superheating in conjunction with boiling, or pressurized water reactors. Steam, in fact, turns out to be a very good cooling medium. The hydrocarbons methane, ethane and benzene have been included merely to illustrate the enormous potential benefit of the higher molar specific heats associated with increasingly complex molecular structure. Unfortunately these are probably totally unacceptable on stability grounds, but are worth including, if only to dispose of any idea that hydrogen represents the ultimate as a gas coolant.

One circuit systems

The section of Table I dealing with power gas-turbine sets refers strictly only to the influence of the choice of gas for a possible secondary circuit containing a power turbine system, and the only aspects considered are the rotating plant size and complexity. These figures are however also approximately applicable to closed cycles, including the reactor in circuit, provided the pressure drop allowance for the latter is not excessive.

It will be seen that the machinery bulk becomes simply inversely proportional to molecular weight, thus making CO_2 or argon look very good for this purpose. In practice we would pay heavily in the size of heat exchangers wanted with the latter gas, but this is an aspect upon which we cannot

conveniently generalize, as so much would depend on detail design.

The subject of power gas turbines is in fact only introduced here to illustrate the point that recommendations about primary circuit coolants are not applicable to such systems.

Potentialities of homogeneous system

Finally, perhaps the most interesting by-product of the foregoing analysis has been derivation of the simple expression for heat rating applicable to homogeneous cores. The rather surprising outcome, that this should be predictable without knowledge of the individual size, shape or even length of the cooling passages is certainly a very convenient one. Apart from permitting us to generalize about coolants, this expression shows the potentialities of the homogeneous system in the most concise possible way, so far, that is, as heat removal is concerned.

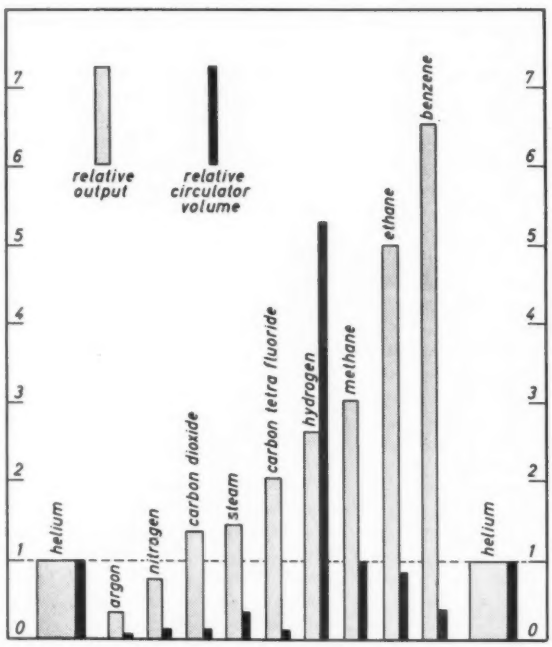


Fig 1 Relative heat output and circulated volume for constant pumping power fraction, core external dimension and voidage, ambient pressure, gas inlet and outlet and core surface temperatures. Duct and heat exchanger bulk would be approx constant

Nomenclature

(*any consistent units*)

		SUGGESTED UNIT
A	Total core frontal area	cm²
a	Total heated surface	cm²
c_p	Specific heat of coolant (at const. pressure)	erg/g/°C
C_M	Molar sp. heat (at const. pressure)	ergs/mol/°C
d_c	Hydraulic mean diameter of fuel element interspaces	cm
f	Friction Factor $= \frac{\Delta P d_c}{2\rho V_c^2 l}$	—
H	Total heat output	erg/sec
h_p	Pumping power	erg/sec
k	Thermal conductivity of gas	erg/sec/cm/°C
k_m	Thermal conductivity of metal fins	erg/sec/cm/°C
l	Core depth	cm
M	Molecular weight	—
ΔP	Pressure drop	dyne/cm
Re	Reynolds' Number $= \frac{\rho V d}{\mu}$	—
S_t	Stanton Number $= \frac{H}{a\rho V_c c_p \Delta t_s}$	—
T_0	Coolant entry temperature	°C
ΔT	Average coolant total temperature rise	°C
Δt_s	Average temperature difference between surface and local coolant	°C
V_c	Velocity in fuel element interspaces	cm/sec
W	Coolant flow	g/sec
x	Coolant voidage fraction	—
μ	Coolant viscosity	g/cm/sec
γ	Ratio of sp. heats	—
ϕ	Core length/extrapolated core length	—

Appendix

With a solid homogeneous core, of frontal area A, pierced by a lattice of uniform section cooling passages, occupying a total voidage fraction x, the relation between required pumping power and resulting rating can be derived as follows:—

$$\Delta P = \frac{2\rho V_c^2 f l}{d_c} \tag{1}$$

$$W = \rho A V_c x \tag{2}$$

$$H = \rho A V_c \Delta T x c_p \tag{3}$$

$$\Delta t_s = \frac{H}{\rho V_c c_p S_t a} \quad \frac{A\Delta T x}{a S_t} \tag{4}$$

$$h_p = \frac{W \Delta P}{\rho} = \frac{2\rho V_c^3 f l A x}{d_c} \tag{5}$$

$$d_c = \frac{4Axl}{a} \tag{6}$$

Combining these,

$$\left(\frac{H}{A\Delta T}\right)^2 = \frac{2x^2 c_p^3 \rho^2}{f} \left(\frac{h_p}{H}\right) S_t \Delta t_s \tag{7}$$

But, for smooth surfaces, $S_t = \frac{1}{2} f$, so,

$$\left(\frac{H}{A\Delta T}\right)^2 = x^2 c_p^3 \rho^2 \left(\frac{h_p}{H}\right) \Delta t_s \tag{8 (eq. 1 of art.)}$$

The actual size and number of the individual coolant passages in the core do not enter explicitly into (8), as they are dependent variables. Thus, from (4)

$$\frac{a}{A} = \frac{x}{S_t} \left(\frac{\Delta T}{\Delta t_s}\right)$$

which, with (6), give:

$$d_c = 4\, S_t l (\Delta t_s / \Delta T) \tag{9}$$

With smooth surfaces, we can take S_t as being given by the empirical relation:

$$S_t = \cdot 028 R_e^{-\cdot 2} \tag{10}$$

In order to avoid successive approximations S_t may be eliminated from (ρ), giving

$$R_e = \left(\frac{H}{A\Delta T}\right) \frac{d_c}{\mu c_p x} \tag{11}$$

Substituting (10) and (11) in (9), we get

$$d_c^{1\cdot 2} = \cdot 112\, l \left(\frac{\Delta t_s}{\Delta T}\right) \left(\frac{H}{A\Delta T}\right)^{-\cdot 2} (\mu c_p x)^{\cdot 2} \tag{12}$$

Where the core takes the practical form of a block of moderator, pierced by circular coolant channels, expression (9) gives their required diameter directly.

Cross-Section

by GRACCHUS

SO INGRAINED is American mistrust of Government participation in anything that could conceivably be done by private enterprise that AEC chairman Lewis Strauss's accusations against the Joint Committee on Atomic Energy should not raise many eyebrows this side of the Atlantic. But I do think it rather amusing that he should consider the Joint Committee's directive telling him to build a gas-cooled reactor of the Calder type as leading to socialism. The vision of the Atomic Energy Authority as a bunch of reds with Sir Edwin Plowden as a sort of commissar is one that I am sure will be appreciated in St Giles Court. Seriously though, it is fascinating that the Americans should at this late date come round to the idea of natural uranium reactors—and gas-cooled ones at that. There is no doubt at all that they have an immense attraction for countries that wish to keep economically independent, whatever the pros and cons in the United States. The Americans are going to find it none too easy to catch up on this particular line but their capacity for doing so should not be underestimated.

THE LONG delay in getting work started at Hunterston—even now the contractors have not been able to move in, due to a further legal delay—has pinpointed very sharply the need for streamlining the reactor siting procedure. In the case of this particular site, of course, a large part of the delay can be ascribed to the unfortunate long illness and subsequent death of the first commissioner Sir James Randall Philip. It is devoutly to be hoped that this will not occur too often. Also the contract was awarded to the GEC Simon-Carves group before the inquiry was held, which made the delay much more apparent. If, instead of announcing the contract last December, it had been postponed until the Minister finally gave his consent there would not have been nearly so much outcry, although of course the delay would have been just the same. The difficulty about this procedure is that the inquiry must obviously know pretty exactly what sort of station is to be built on the site and this cannot be known until the electricity authority has chosen a design from amongst those tendered.

In the report on the Hunterston inquiry, it is revealed that the successful tender was based on 'a *typical*, not actual site.' This must make things very difficult for the designers. It seems to me that if these public inquiries are to be held every time a nuclear power station site is selected then somehow things must be arranged so that the tenders can be asked for based on a definite site and that when the successful bid is chosen the contractor must be able to move right in.

THE CHIEF of one of Britain's biggest shipbuilding concerns, Harland and Wolff of Belfast, has recently pronounced his views on nuclear propulsion (see *Worldview*). Doubtless, a certain amount of caution is no bad thing in dealing with a subject which can get close to science fiction but Sir Frederick Rebbeck's gloomy prognostications ('a quarter of a century before you see anything very active going down to the sea') are surely going to the opposite extreme. Perhaps he has never heard of the new United States Navy? America has now built its very last conventional submarine and has at the moment two atomic submarines in commission with a further 13 on the stocks or definitely authorized by Congress. In addition, a 14,000-ton guided missile cruiser and an 80,000-ton carrier have been ordered by the US Navy.

Now, I know Sir Frederick was referring specifically to merchant ships and naval vessels are not built with the same regard to economics. Nevertheless, there is no doubt at all now that nuclear power is a perfectly feasible method of ship propulsion and that economical operation is only a matter of straightforward engineering. Nor are all current propulsion projects naval: last October President Eisenhower authorized a 20,000-h.p. passenger-cargo liner and the Russians have a 16,000-ton icebreaker due for launching this year. Even in this country things are moving quite fast. In addition to HMS *Dreadnought*, at least four of Sir Frederick's competitors are known to be actively engaged in A-ship design and two of them have actually announced some details—60,000-ton tankers in each case.

What makes Sir Frederick's speech all the more mysterious is that his firm have been advertising for some considerable time that they are 'suppliers of plant and equipment used in the production of nuclear energy.'

No, Sir Frederick, I think you are wrong and that five years from now will certainly see something extremely active going down to the sea—safely enclosed, I hope, in a stout pressure vessel.

ARE FUSION reactors really closer than we think? For some time now I have had the impression that the AEA, or at least its Research Group, has lost interest in fission. This is of course a gross oversimplification but all sorts of things are beginning to add up to a picture. The 3rd Annual Report, for example, says the old 3-stage reactor development programme has been abandoned in favour of 'a more flexible pattern of development.' This sounds vague enough to be covering something. Also, recent public statements by prominent AEA officials indicate a period of about 15-20 years both as a useful development life for the Calder type reactor and also for the practical realization of the fusion reactor. The coincidence is probably no mere accident. Work is no doubt going ahead on various types of enriched-fuel fission reactors for propulsion and other applications where relatively small units are needed. But as far as central power stations are concerned my guess is that we are now only interested in the Calder approach, believing that this will do all we need until the thermonuclear reactor is a working proposition. Development of this theme however can only be speculation since it is impossible to find out what really is going on. In June a conference on thermonuclear work was held at Harwell and although this time a number of British firms were invited, as usual the Press was banned. I have often heard complaints about press handling of thermonuclear news. This is bound to continue until the AEA are prepared to let us have some really hard facts.

Next year's Geneva conference is to include a session on fusion reactors. I well remember the sensation caused at the 1955 conference when the Russians gave details of a fission power station complete and working. Better prepared this time, it will not surprise me at all to hear of a thermonuclear reactor actually in operation. It would be nice if it were a British delegate that gave the news.

A READER sends me this from the *Cyprus Mail*—

> 'Britain's latest and most up-to-date atom power station . . . has as its centrepiece a unique giant steel sphere 135ft in diameter constructed to house a fast breeding rector.'

That fast?

Pye at Het Atoom

In the swimming pool reactor at the Het Atoom exhibition (*Worldview*, July) observation of the position and behaviour of the control rods is achieved by a Pye spherical static underwater TV camera. Observations are made on monitors outside the reactor container.

Pye are showing a range of nuclear equipment at the exhibition, open at Schiphol Airport until September 15. Right and left hand manipulators are set up as working exhibits, with the control end outside a concrete enclosure and used to handle test tubes of liquid. Pye produce a standard range of manipulators which can be fixed into walls of thickness from 2ft to 4ft 6in. or more, with master and slave ends capable of elongation up to 39in. With power assistance, specially designed units can be extended to approximately 17ft. Jaws can be designed to suit any specific handling task. Industrial television is also being shown in conjunction with a microscope. This is designed for remote observation of radioactive metallurgical specimens and at the exhibition is placed next to the manipulator to show how the samples can be changed remotely.

The Atom 1957

This is the name of an exhibition organized by the *Sunday Times* in association with the UKAEA to be held in Park Lane House from October 8 to 26. Scope of the exhibition, which will be presented in a simple, non-technical manner, will include the potential of atomic energy in industry, medicine, agriculture and research. A section specially designed to advise younger visitors will be devoted to careers. Lectures and film shows will also form part of the exhibition. Opening hours will be 11.30 a.m. to 9.30 p.m. and admission 1s.

BOG equipment at Farnborough

Several new developments will be exhibited for the first time at Farnborough by British Oxygen Gases Ltd. With the new Argonarc spot welding equipment, incorporating the Argonarc composite rectifier 150 and new crater filling devices, it is possible to produce high strength spot welds to the maximum consistency required for aircraft structures and engine components in stainless steels, and other high strength alloys within this group.

The automatic arc length control unit for machine Argonarc welding is the first British made set of its kind for both a.c. and d.c. welding. This is intended for use where an extremely high degree of weld consistency is required.

The new Argonarc cutting process enables aluminium plate up to 1in. thickness to be cut at very high speeds—1000ft per hour for ¼in. thick plates—using either high purity nitrogen or mixtures of argon and hydrogen or nitrogen and hydrogen. A clean cut edge is produced with little or no adhering dross, and the process can be used either manually or in conjunction with automatic profile or straight line cutting machines.

A new liquid nitrogen system for creating an inert atmosphere in aircraft fuel tanks and so reducing fire risks will also be shown by British Oxygen Engineering Ltd. The system has been developed after three years' work in collaboration with the Ministry of Supply.

Measuring rotor diameters

A small distance bridge to measure the increase in diameter of turbine rotors at working speeds has been developed by the Wayne Kerr Laboratories in conjunction with Bristol Aero Engines Ltd, and this will be on show at Farnborough from September 2-8. To achieve maximum efficiency in the operation of aircraft turbine engines, the clearance between the rotor blades and the outer casing must be kept to a minimum, when nearly all the energy in the jet system is imparted to the rotor blades. At the enormous speeds encountered in modern engines, say 40,000 rpm, there is a tendency for the metal in the rotors to flow due to centrifugal force effects. This results in a slight increase in rotor diameter, and the clearance between blades and casing must be designed taking this factor into account.

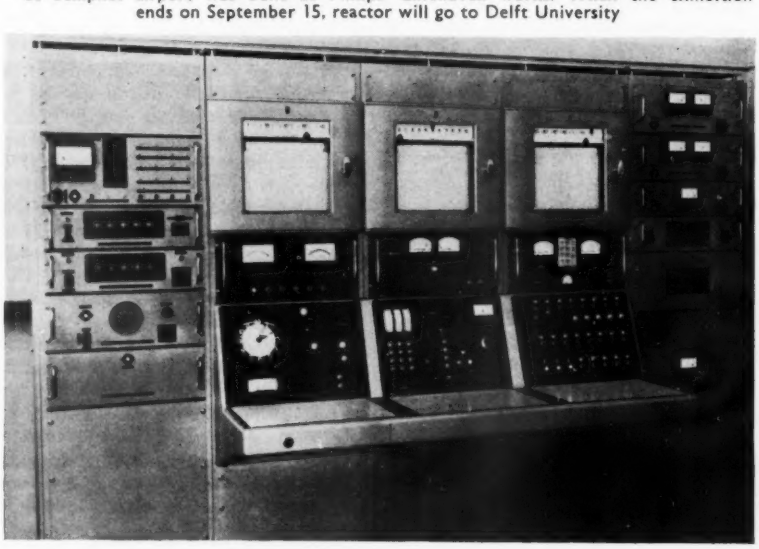
The Wayne Kerr measuring device uses a transformer ratio arm bridge which can detect an extremely small change in capacitance at the ends of cables of almost any length. A small probe is fixed very near the rotor periphery and the capacity between them measured. Increase of rotor diameter is given precisely by increase in capacity.

Gen Dynamics merger discussed

In New York last month the possibility of a merger between the General Dynamics Corporation and the Liquid Carbonic Corporation was discussed. The boards of both companies approved in principle an agreement by which Liquid Carbonic would become a division of General Dynamics, with Rex L. Nichoison, present president of Liquid Carbonic, becoming senior executive of the division. 'Our philosophy as a corporation is to develop the tremendous potentials of the aerodynamic, astronautic, hydrodynamic, electronic and nuclear technologies in which Dynamics is actively engaged', said Frank Pace, General Dynamics president. 'A logical extension, therefore, of the corporation's activities is an entry into the chemical field, especially with respect to compressed and liquid gases which are extensively interrelated with missiles, aircraft, applications of nuclear energy, and electronics.'

General Dynamics built USS *Nautilus* and *Seawolf*, and recently signed an agreement with Texas Atomic Energy Research Foundation for a four year $M10 jointly-sponsored research pro-

SEEN AT HET ATOOM Control desk for AMF swimming pool reactor now working at Schiphol airport was built at Philips' Eindhoven works. When the exhibition ends on September 15, reactor will go to Delft University



AIR-CONDITIONED ASSEMBLY In Avo Ltd's new dust-free zone, instruments are built, calibrated and tested. Personnel and visitors alike have to comply with exacting standards of cleanliness

gramme in the field of thermo-nuclear power.

Meanwhile one of America's senior nuclear physicists, Professor Donald W. Kerst, the inventor of the betatron, has joined the John Jay Hopkins laboratory for pure and applied science of General Dynamics Corporation's General Atomic Division. At present technical director of Midwestern Universities Research Association, Dr Kerst will be project leader of the laboratory's controlled thermonuclear energy research programme mentioned above. The aim of the programme is the understanding and production of heavy hydrogen reactions at high temperatures under controlled conditions. Dr Kerst has been an important consultant in the AEC's controlled fusion research. From 1940 to 1941 he worked at General Electric's research laboratory where he built a 20 million electron volt betatron. This machine was brought to the University of Illinois in 1941 for physics experiments. During the war as a member of the Manhattan Engineer Project he was the leader of the Los Alamos Scientific Laboratory group that constructed the first enriched uranium chain reaction the water-boiler reactor.

Weatherfoil heating exhibition

Two private exhibitions of their heating equipment are to be held in Birmingham and Glasgow by the Dravo Division of Weatherfoil Ltd. They should be of particular interest to architects, surveyors, heating engineers and anyone concerned with the heating of factories, multi-storied offices, flats and workshops. Technical staff of Weatherfoil will be present at both occasions.

The exhibitions will be at the following places: at the Exchange and Engineering Centre, Birmingham, from September 24 to 26, between 10 and 6; at the East Room, McLellan Galleries, Glasgow, from October 1 to 3, between 10 and 6.

Irradiated polythene by BICC

The manufacture of several types of small coaxial radio frequency cables insulated with irradiated polythene is announced by British Insulated Callender's Cables Ltd. The insulation is irradiated to reduce deformation of the core during soldering, but otherwise these cables are of a standard construction. Although the power factor is slightly increased, other electrical characteristics are virtually unimpaired, and the cables are recommended for normal r.f. applications at frequencies up to 200 Mc/s.

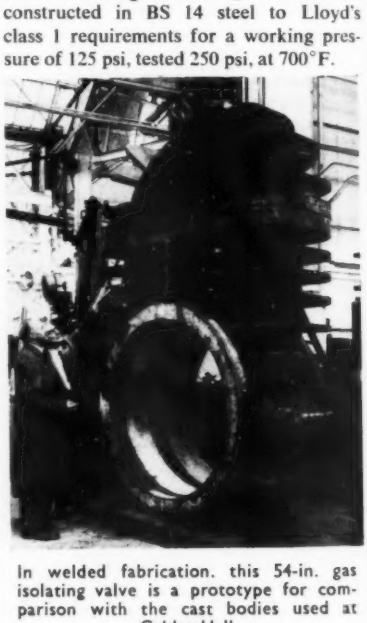
Irradiated polythene equipment wires with improved soldering properties are also available together with a similar type of wire which is also satisfactory for continuous operation up to 100°C. The latter may also be operated at 120°C for 1500 hours and for shorter periods, approximately 1 hour, up to 250°C, provided the insulation is not placed in contact with bare copper.

Turner form subsidiary

As a result of their extensive experience in the field of hydraulics and pneumatics for the aircraft industry, the Turner Manufacturing Co Ltd, Wolverhampton, have formed a subsidiary company, Hydraulics and Pneumatics Ltd, for the manufacture of hydraulics and pneumatics for general industrial requirements. By the terms of an agreement recently made with the Modernair Corporation of America, Hydraulics and Pneumatics Ltd will manufacture in Britain the up to date range of pneumatic components developed by the American company. They have also introduced a comprehensive range of hydraulic equipment comprising high pressure automatic variable delivery pumps, high pressure gear pumps, hand operated and solenoid operated selectors, and cylinders. Some of these will be on show at the Engineering, Marine, Welding and Nuclear Energy Exhibition.

Prototype reactor gas valve

The body of a 54in. full way valve, developed from the cast steel type supplied by J. Blakeborough & Sons Ltd for Calder A, has been fabricated by Davey, Paxman & Co Ltd. Made under contract for the UKAEA, this is a prototype and no particular destination has been officially named. The fabricated body is now with Blakeborough who will fit it with the valve components and control gear and be responsible for the final machining and testing. The valve is constructed in BS 14 steel to Lloyd's class 1 requirements for a working pressure of 125 psi, tested 250 psi, at 700°F.



In welded fabrication, this 54-in. gas isolating valve is a prototype for comparison with the cast bodies used at Calder Hall

New radiation protection service

Philips Electrical Ltd announce the introduction of a radiation protection service to be operated by the company's Research & Control Instruments Division. Service offers consultation on X-radiation protection problems, without cost or obligation, and provides for the planning and equipping of complete X-ray departments with all necessary protective measures, as well as the revision of such measures in existing departments. Other features of the service are the supply of all types of protective media

such as lead, lead ply, Philitex blocks (barium sulphate) and protective doors; complete installations to specification; advice on suitable electrical interlocks and other safety measures; the provision of special handling gear for X-ray equipment—this can be integrated with the design and protection of the X-ray department.

Further information from Philips Electrical Ltd, Research & Control Instruments Division, Century House, Shaftesbury Avenue, London, WC2.

Siemens and Edison Swan merge

The two AEI subsidiaries, Siemens Brothers & Co Ltd and the Edison Swan Electric Co Ltd merged recently into a new manufacturing and selling organization, Siemens Edison Swan Ltd. Edison Swan has been a member of AEI since 1928 and Siemens Brothers since 1955, and for the last two years Siemens-Ediswan Ltd has acted as a coordinating body for the two companies. This latest move completes the integration. The new company will own and operate a number of factories and make a wide range of light engineering products, including telephone and telecommunication equipment, radio and television valves, cables, marine equipment and domestic electric equipment. It will employ 21,000 people in 4 million square feet of factory space.

Chairman of Siemens Edison Swan is Lord Chandos, chairman of AEI; managing director of the new company is Dr. J. N. Aldington, a director of Siemens since 1949.

APV agreement with Rosenblad

The APV Co Ltd has concluded an agreement with the Rosenblad Co of Stockholm for the exclusive manufacture and sale of the Rosenblad heat exchanger in the United Kingdom. APV will also be responsible for its sale in the Commonwealth, except Canada, and in the Middle East. Manufacturing and selling rights were previously held by Ashmore, Benson, Pease & Co Ltd. The Rosenblad is a heat exchanger of spiral construction that can be manufactured in a wide range of metals and sizes and in various types. Its applications are complementary to those of the *Paraflow* plate type of heat exchanger long associated with the name of APV. This, together with the manufacture of tube and shell heat exchangers, greatly widens the field of duty for which APV can offer heat exchangers.

Computer exhibition next year

An Electronic Computer Exhibition, to include data handling equipment of all kinds, is to be held at Olympia from November 28 to December 4, 1958. The first of its kind to be held in Great Britain, it is being sponsored by a joint committee of the Radio Communication and Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association. Concurrently with the exhibition there will be an international symposium, organized by the NPL, at which papers dealing with the applications of computers to problems in business, industry and science will be read and discussed.

The exhibition will show complete systems of automatic electronic data processing equipment, including digital and analogue computers, all the new forms of magnetic input and output equipments, high-speed printers and telemetering systems. Applications and demonstrations of this equipment will cover financial management and administration, factory control and industrial and scientific research.

British Oxygen-Ferranti cooperation

An extensive twelve months' research cooperation between the British Oxygen Company and Ferranti Ltd, has resulted in great advances in the field of computer controlled flame cutting machines. The new equipment which will result from this link-up is the first of its kind in the world, and will have application in all branches of heavy engineering and particularly in atomic energy and chemical engineering. It is essentially an application of Ferranti machine tool control methods to new developments by British Oxygen in the field of oxygen cutting. As well as fully automatic operation of the profiling process, the system includes special features for controlling automatically the gas supplies to the cutting blow pipes, automatic ignition, pre-heat flame monitoring, nozzle-height sensing and cutter head rotation. Demonstrations of the first experimental machine are expected to take place in the autumn.

New research lab opened

Radio Heaters Ltd have opened a new research laboratory at Wokingham, Berkshire, to do work on high frequency induction and dielectric heating equipments of all types. The services of this new laboratory will be available to any potential industrial user of this type of equipment. The work of the laboratory includes induction heating for brazing, soldering, hardening and annealing, heavy induction plant for billet heating and melting, radio frequency dielectric heating plant for the compression section of the plastic moulding industry, the food industry, drying, and rapid wood glue setting.

Research is also being done on the electronic bonding and welding of thermoplastic sheeting materials, including problems associated with electronic quilting and upholstery in high speed automatic presses.

Met-Vick tank for CERN

A 40 ft, 9 ton section of steel vacuum tank was dispatched last month from the Trafford Park works of Metropolitan-Vickers to Geneva where it will form part of the 50MeV proton linear accelerator of the Conseil Européen pour la Recherche Nucléaire. When completed, the accelerator will be 100 ft long. Equipment was carried on a lorry and trailer

Section of a vacuum tank for CERN's 50 MeV reactor at Geneva leaves Met-Vick's Trafford Park works

specially adapted to permit relative movement without involving the risk of distorting the tank. On arrival at Tilbury, the lorry was driven direct on board the 'drive-on, drive-off' ferry of the Transport Ferry Service, and the journey to Switzerland was continued without disturbing the load.

In brief

The Solartron Electronic Group Ltd, Thames Ditton, Surrey, has decided to sell no longer through agents in the United Kingdom. In future, all inquiries should be sent direct to the Group at the Thames Ditton headquarters.

Vitro Engineering Co have been awarded a contract to design and construct 500MW (thermal) reactor near Rome for the Italian Government.

Norris Warming Co Ltd, heating, ventilating and air-conditioning engineers, and F. A. Norris & Co Ltd, constructional steelwork specialists, have opened new offices at 38-40 Elm Grove, Portsmouth.

Ministry of Commerce is to build and let a new factory to **Lee Guinness Ltd.** Located near the company's existing factory at Newtownards, Co Down, it will produce automatic control gear, and employ between 400 and 500.

William Beardmore & Co Ltd of Parkhead Steelworks, Glasgow, E1, have changed their London office address to 11 Hamilton Place, London, W1.

Industrial graphite conference

The Society of Chemical Industry is to hold a three-day conference on industrial carbon and graphite from September 24 to 26, at the William Beveridge Hall, London University. Considerable interest has been shown by various countries including the USA, Russia, France and the Netherlands and more than fifty papers have been submitted. Contributions will come from government departments in Britain and overseas, and industry will be represented by applicational papers.

There will be a whole session devoted to graphite in the nuclear power industry which will include the following papers: *The use of graphite as a moderator in nuclear reactors* by E. E. Lockett (Harwell); *Some physical properties of graphite as affected by high temperature and irradiation* by John E. Hove (Atomics International, USA); *The effect of neutron irradiation on the physical properties of graphite* by J. H. W. Simmonds (Harwell); *Compatibility problems of graphite moderators* by Dr A. B. McIntosh, W. G. O'Driscoll and Dr C. Tyzack (UKAEA, Culcheth) and *Problems in the production of nuclear graphite* by P. Cornuault and H. des Rochettes (Société Péchiney, France).

In a session on the manufacture of carbon and graphite, M. S. T. Price and F. W. Yeats (Harwell) will speak on *The Harwell experimental graphite plant.* Three members of the GEC Research Laboratories, H. W. Davidson, Dr T. B. Copestake and Dr B. L. Tonge will present a paper on *Reaction of graphite with carbon dioxide at temperatures near 500°C.*

Further details of the conference and application forms can be obtained from the Assistant Secretary, Society of Chemical Industry, 14 Belgrave Square, London, SW1, or from the Hon Sec of the conference committee, E. A. Smith, Acheson Industries (Europe) Ltd, 18 Pall Mall, London, SW1. Conference membership includes a set of preprints of the papers. An exhibition of carbon and graphite will be held in the chemical engineering department, University College, London, during the conference.

BA to discuss fusion

This year the British Association for the Advancement of Science meets in Dublin from September 4 to 11. President for 1957 is Prof P. M. S. Blackett and the subject of his address will be *Technology and world advancement.* Several sections will contribute to this theme, notably one on industrial applications of thermonuclear reactions. Sir George Thomson will speak on *Controlled thermonuclear reactions* and J. D. Lawson on *Nuclear fusion as a possible source of power.* One of the evening discourses will be by Dr H. J. Bhabha, chairman of the Indian Atomic Energy Commission, on *The economics of atomic power development in the Indian atomic energy programme.* CEA chairman, Sir Josiah Eccles, will speak on *Energy and power supply*, reviewing basic sources of energy, the scope for their application to power production and the pattern of future exploitation in Great Britain. In the same session, Prof O. A. Saunders, Imperial College, will discuss *Engineering problems associated with heat transfer.*

No scientific qualifications are required for membership of the British Association. Associate membership costs 2 guineas for adults, 10 shillings for students and school children. Application should be made to the secretary, G. V. Allen, at Burlington House, London W1.

IRE convention at Cambridge

The convention on Electronics and Automation held in Cambridge from June 26 to July 1 by the British Institution of Radio Engineers was attended by more than 450 delegates, a high proportion from abroad. Several aspects of nuclear energy received attention. H. Bisby of the UKAEA gave a survey of radiometric instrumentation used for process control and discussed design features of plant instruments covering radioactivity assay by direct emission and absorption techniques.

Dealing with monitoring instruments in the first category, Bisby explained that the prime purpose is to present information on process behaviour in a form suitable for both interpretation by an operator and post analysis, and gave examples of measurement of particular types of radiation defined by the product concerned. He also discussed those cases where direct access to process streams is precluded either physically, or by a lack of detector sensitivity, and when automatic sampling techniques are necessary. Some of the methods he described were those now being used in the UKAEA factories.

In two specialist papers, *Fluid density measurements by gamma-ray absorption* by R. Y. Parry and A. E. H. Hodgson and *The role of gamma-ray level detection systems in chemical plant instrumentation* by E. W. Jones, the special advantage of the radioactive method—that it can operate entirely from outside the vessel—was emphasized, and the precision of measurement possible was given. For instance, changes in specific gravity of 0·2% of liquids in steel walled pipes of up to 14 in. dia. could be detected, and levels could be measured with a precision of $\pm\frac{1}{16}$ in.

Nuclear courses at Borough Poly

The courses in nuclear technology at Borough Polytechnic begin again in October. Evening lectures by specialists from the UKAEA, industry and colleges are held weekly, including a series of 24 lectures on nuclear power starting October 10, eight in nucleonic circuitry from October 2, fifteen on nuclear particle techniques from November 27, ten on radiation chemistry from October 14, and five on reactor instrumentation and control from April 17. Of the two laboratory courses on nucleonic techniques and measurements, the two-month full time courses beginning on October 14 and April 14 should be of particular value. There is also a part-time course held on Friday afternoon and evening starting on October 11 or on Tuesday morning and afternoon from October 8. These courses comprise laboratory work with supporting lectures on the properties of nuclear radiation, nuclear techniques and radioisotope measurement and applications.

Further details are obtainable from the Secretary, Borough Polytechnic, Borough Road, London, SE1.

Low temperature gas separation

The Low Temperature Group of the Physical Society and the Institution of Chemical Engineers are jointly organizing a one-day conference on *Recent developments in industrial low temperature gas separation.* It will be held on Tuesday, November 26, at The Royal Institution. Tentative programme includes *The low temperature separation of light hydrocarbons*, by C. C. King, *Purification of hydrogen for distillation* by W. H. Denton and *Industrial tests on hydrogen distillation* by R. Condamin.

BS on inch/metric conversion

Conversion of inch and metric sizes on engineering drawings is of great importance in trade with countries using the metric system. There has long been a need for a standard practice which gives the essential accuracy required for precise dimensional interchangeability. This need has now been met with the publication of BS 2856, *Precise conversion of inch and metric sizes on engineering drawings.* This lays down an optimum fineness of rounding the converted size

so that conversion is of the required precision but at the same time avoids an excessive number of decimal places in the converted size.

The recommended procedure of conversion takes the form of simple rules for the successive steps in conversion and deals with typical cases under the headings: simple features having two limits of size; groups of simple positional features; datum dimensions; and untoleranced dimensions. Examples of the application of the rules are given for each of these cases. Tables of conversion from inches to millimetres, and vice versa, are included in an appendix.

Copies of the standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W1, price 3s 6d.

Non-destructive testing committee

In recent years the subject of the non-destructive testing of materials has achieved great importance. Societies have been formed with this as their main interest, while other Institutions of longer standing have devoted a more or less substantial part of their technical programmes to the discussion of non-destructive testing principles and techniques At the beginning of this year a combined appeal was made by a number of societies to the Joint Committee on Materials and their Testing to foster the establishment of a national committee as a focus in the UK for all interest in this aspect of testing. The Joint Committee accordingly set up a sub-committee to examine this request which has now approved the constitution, terms of reference and rules for a committee to be known as The British National Committee for Non-destructive Testing. Pending an election, the chairman of the British National Committee will be C. H. Stanger, AMICE, AIStructE, who took the Chair of the investigating sub-committee.

BOOKS

Aiming high

A Target for Euratom Luxembourg 1957: European Coal and Steel Community, High Authority

The broad outlines of the report to Euratom by its 'three wise men'—Louis Armand, Franz Etzel and Francesco Giordani—have been known for some time, but the complete report has just been published. Very briefly, the Armand committee recommend that the six Euratom countries should aim at having installed by 1965 a total nuclear generating capacity of 15 million kW and they envisage that this might be divided about equally between British-type natural uranium reactors and American pressurized or boiling water reactors. The economic evaluation of these types is gone into very thoroughly, although this section is somewhat marred by misprints—especially a confusion between dollars and pounds.

On the question of enriched fuel, Euratom now seem noticeably less enthusiastic on diffusion plants than they were believed to be at one time and the report says it is 'probable' that economic ways of using plutonium will be found. As already reported, the wise men are on record as being very impressed with the idea of natural (or even slightly depleted!) uranium reactors moderated by heavy water. In a report of striking phrases, one stands out:

> Every year that is lost in constructing nuclear power stations means that conventional stations, requiring increased oil or coal imports—and which continue to consume oil or coal throughout their lifetime of twenty or thirty years—will be built instead. In view of this situation, Europe must within the limits set by the pattern of electricity production, construct nuclear stations as rapidly as possible.

To achieve this, the wise men say that first orders for plant must be placed by the end of 1958 . . . no doubt Mr Maudling, the newly appointed Minister for European integration, is fully aware of all this.

Nuclear power for management

The Industrial Challenge of Nuclear Energy Published by OEEC London 1957: HMSO Price 30s

In April 1957 the Organization for European Economic Co-operation held a conference in Paris on 'Nuclear Energy for Management' and followed this with a similar conference at Amsterdam in June. This volume includes all the lectures given at the Paris meeting and forms an excellent survey of the present status and future prospects for nuclear energy developments in Europe.

These OEEC meetings are obviously of great value to industrialists and the publication of the proceedings should ensure them reaching a very wide public. Reading the contributions—many of them from countries hardly yet in the picture as far as practical atomic energy is concerned—one is struck with the speed with which Europe is learning. The book should be read carefully by top management circles in Britain, for the world 'Challenge' in the title is not merely a literary device but a very real concept.

A map is included which gives the location of all nuclear energy undertakings in Europe. The usefulness would have been greatly increased had it included a few more topographical features: as it is, the establishments are shown on an otherwise blank space.

No longer fiction

Space Research and Exploration D. R. Bates (Ed) 5¾ by 8¾ in. 244 pp. London 1957: Eyre & Spottiswoode. Price 25s

The news that the Royal Aeronautical Society and the British Interplanetary Society recently cooperated in an international conference on high altitude and satellite rockets means presumably that the subject is now invested with respectability. The appearance of Professor Bates' book at this time is thus welcome—particularly since this author's treatment of their themes is eminently respectable. It consists really of monographs on various topics by twelve well-known authorities.

After an admirable introduction and history by Mr Clarke and Mr Cleator respectively, sections follow on rockets, the upper atmosphere, cosmic radiation (by Dr L. R. Shepherd, Harwell), meteor hazards, the earth satellite programme (Prof H. S. W. Massey), the manned satellite station, interplanetary orbits, space navigation, medical and biological problems, conditions on the moon and nearer planets.

The treatment is on the whole simple and when recourse has to be made to mathematics, this is banished to appendixes. On nuclear energy for rocket flight, there seems very little hope at the moment. Mr J. Humphries shows that using a nuclear reactor the thrust obtainable is very little better than that from a high energy chemical propellant. It might be improved using a gaseous reactor but the size would have to be gigantic. Finally there is the ion rocket and Humphries

believes that it would only be of use for low thrust journeys such as those between satellite orbits.

The book is well produced and forms an excellent introduction to a subject upon which we are still on the edge.

Simple knowhow

Nuclear Power Engineering Henry C. Schwenk, Robert H. Shannon and B. G. A. Skrotski. 5½ in. by 8½ in. 319 pp. London 1957: McGraw-Hill. Price 49s

Written primarily for engineers with but scant knowledge of modern physics, *Nuclear Power Engineering* is a valuable introduction to a subject which many otherwise well qualified readers find troublesome. For the first eight chapters the authors steer a skilful course between vulgar oversimplification and the complete treatment and manages by the use of extremely clever illustrations and captions to convey vividly the notions of nuclear interactions, fission and chain reactions. This is not to say that mathematics is completely out: the principal fission formulae are quoted without derivation and their use is demonstrated.

The latter part of the book deals with engineering problems of removing and utilizing reactor heat and of reactor control and good though it is, in a fairly elementary way, it completely ignores the important contribution to nuclear power knowledge of the Calder Hall type of reactor. Britain, in fact, comes out very badly, for in the section on breeder reactors, Dounreay is not even mentioned although EBR2—construction of which has just started—is treated as though it were already in operation. If a second edition is called for—as it certainly should be—these points should be rectified.

A commendable feature of *Nuclear Power Engineering* are the questions at the end of each chapter. These are not just mathematical exercises but a thought-provoking quiz game.

Shorter notices

Concise Encyclopedia of Atomic Energy Ed. Frank Gaynor 5½ in. by 8¼ in. 204 pp. London 1957: Peter Owen. Price 37s. 6d.

The best that can be said about this is that when it was first published in the United States in 1950 it was probably very good: today, in the post-Geneva nuclear world it is simply not good enough. People like Fermi and Einstein are entered as still alive, a catalogue of US reactors dates from 1949 and important reactor concepts such as buckling, neutron diffusion and slowing down length are not mentioned at all. Nevertheless the book could form the basis of a useful reference work but needs a complete revision.

Fyzika Deleniya Atomnikh Yader (The physics of nuclear fission) Moscow 1957: Atomizdat

This is a collection of reprinted articles from the Soviet journal Atomnaya Energiya. It includes twelve contributions on various fission questions.

Atomic Power for Peace Vol 3. Radioisotopes and Tracers in Industry, Agriculture and Medicine. W. J. Vogt. Johannesburg 1957: English Electric Co of South Africa (Pty) Ltd. Unitas Building. 42 Marshall St. PO Box 2387

The first edition of a volume in a series to include uranium, reactors, isotopes, accelerators and a glossary, the present book is a well conceived and tautly written introduction to a wide subject. Duplicated, but well bound and illustrated, the book is evidently written for the non-specialist but a certain amount of general scientic background would certainly be useful. In printed form *Atomic Power for Peace Vol 3* would certainly prove a useful addition to the literature.

British Nucleonic Instruments 1957. London 1957: Scientific Instrument Manufacturers Association, 20 Queen Anne St. W1. Price 10s. 6d.

The fourth edition of SIMA's well-known guide to nucleonic instrumentation appears with a new title and new format. The 57 member firms of the Nucleonics Group have cooperated to give the reader a summary of their products and details of some of the more interesting ones.

In a foreword, Sir John Cockcroft pays tribute to the British instrument industry and to the way it has taken over the early development work done at Harwell. Britain, he declared, can now claim a range of nuclear measuring instruments and accessories of proved design second to none in the world. The volume also includes some useful technical data.

Publications received

Automatic Regulators and Stabilizers—Catalogue S-574. More than a mere illustrated price list, Claude Lyons' latest publication includes full technical descriptions, specifications and performance characteristics of their products described in the title. Of particular interest are the BAVR-E series of automatic voltage stabilizers giving control to plus or minus 0·15 pct. There is also a new type of high-speed automatic voltage regulator —type TCVR—which uses thyratrons instead of relays. These units are suitable for input to computers and business machines. Claude Lyons Ltd, Valley Works, Ware Rd, Hoddesdon, Herts.

Metal Degreasing by Trichlorethylene. Booklet gives full details of process. Imperial Chemical Industries, Millbank, London, SW1.

Caposite Moulded Thermal Insulation Materials. Specifications and technical data on amosite asbestos thermal insulation materials suitable for boiler ducting etc. Cape Asbestos Co Ltd, 114-116 Park St, London, W1.

Irradiated Polythene Tape. Technical report gives specification and properties of new product from TI's research laboratories. Three grades now available, suitable for packings, wrappings and electrical applications. Tube Investments Ltd, The Adelphi, London, WC2.

'Somerford' transformers and chokes. Loose-leaf catalogue gives full details and prices. Most items available 'off-shelf.' Gardners Radio Ltd, Somerford, Christchurch, Hants.

Quasi-Arc Welding News No 4 includes article on welding Dounreay Fast Reactor containment sphere. Quasi-Arc Ltd. Bilston, Staffs.

Engineering for Atomic Power. An attractive brochure describing their considerable achievements in the building of atomic power plants in the United States, the best known of which is Oak Ridge National Laboratory. Stone and Webster Engineering Corporation, 49 Federal St, Boston, Mass.

Universal Electronic Batching Counter is described in leaflet from Atkins, Robertson & Whiteford Ltd, Industrial Estate, Thornliebank, Glasgow.

Two new product specifications—strip chart temperature recorder (E57-8), electrical control station (E75-4) have been issued by Bailey Meters and Controls Ltd, 153 Moorgate, London, EC2.

Measuring Equipment is subject of new catalogue from The Wayne Kerr Laboratories Ltd, New Malden, Surrey.

Baldwin Fluid Power—comprehensive catalogue gives full details of pneumatic and low pressure hydraulic equipment. Baldwin Instrument Co Ltd, Brooklands Works, Dartford, Kent.

Fibreglass R50 air filter units are described in new leaflet. Fibreglass Ltd, Ravenshead, St Helens, Lancs.

RESEARCH REPORTS

United Kingdom

*The following reports have been made available to the public by the United Kingdom Atomic Energy Authority. They may be borrowed or photocopies obtained from the Science Library, London, Department of Industrial and Forensic Science, Belfast, the Mitchell Library, Glasgow, and the Central Libraries at Acton, Birmingham, Bristol, Kingston-upon-Hull, Leeds, Liverpool, Manchester, Newcastle-upon-Tyne and Sheffield. They are also deposited in the Copyright Libraries (i.e. British Museum; University Library, Cambridge; Radcliffe Science Library, Oxford; National Library of Scotland, Edinburgh; National Library of Wales, Aberystwyth) and in the Patent Office Library. Reports marked * may be purchased from Her Majesty's Stationery Office.*

Reports are also available in the United States, from the USAEC depository libraries, a list of which will be found in NUCLEAR SCIENCE ABSTRACTS. Reports for sale may be purchased in the United States from: Sales Section, British Information Services, 30 Rockefeller Plaza, New York 20, N.Y.

AERE Harwell

Proceedings of the Tripartite Conference on Cross-sections of Fissile Nuclei. *J. J. Pattenden*, ed. (Jan 21, 1957. 95 pp) AERE NP/R 2076 (Rev) 21s 3d*

Table of consistent nuclear data for U-233, U-235 and Pu-239 for 2200 m/sec. neutron. *P. A. Egelstaff, K. W. Morton, J. E. Sanders.* (1957. 9 pp) AERE NP/R 2140 1s 9d*

Fuel recycling in equilibrium thorium single region thermal reactors. *J. J. Syrett, J. A. Dyson.* (April 1, 1957. 20 pp) AERE R/R 2167

Studies on the occurrence of undamped oscillations in a circulating liquid metal fuel reactor. *J. J. Thompson.* (Feb, 1957. 10 pp) AERE R/R 2192 2s*

Physics of heterogeneous, light water moderated reactors. A bibliography of published and unclassified report literature. *A. Potter.* (Jan, 1957. 24 pp) 3s 6d*

Industrial Group

The sampling of carbon dioxide under pressure prior to the determination of oil (March 8, 1957. 5 pp) IGO-AM/W-77

The determination of total dissolved solids and total suspended solids in natural, treated, boiler feed and boiler waters. (May 28, 1957. 4 pp) IGO-AM/W-85

The determination of the total hardness of boiler water (titration with soap solution). May 28, 1957. 4 pp IGO-AM/W-86

The determination of total dissolved solids in boiler waters (specific gravity measurement). (May 28, 1957. 3 pp) IGO-AM/W-87

The determination of alkalinity in natural in natural water, boiler feed water and treated water. (May 28, 1957. 3 pp) IGO-AM/W-88

The determination of alkalinity in boiler water. (May 28, 1957. 3 pp) IGO-AM/W-89

The determination of calcium and magnesium hardness in natural, treated, boiler feed and boiler waters (EDTA titration). (May 28, 1957. 5 pp) IGO-AM/W-90

The determination of trace amounts of calcium and magnesium hardness in natural, treated, boiler feed and boiler waters (EDTA titration). May 28, 1957. 5 pp) IGO-AM/W-91

The determination of boron in methanol distillates arising from boron separation procedures (curcumin - oxalic acid method). (May 21, 1957. 7 pp) IGO-AM/W-92

The determination of boron in methanol and in methanol distillates arising from boron separation procedures (curcumin-chlorophenol method). (May 27, 1957. 7 pp) IGO-AM/W-93

The determination of the surface lead and cadmium contamination on stainless steel tubing (polaragraphic method) (May 5, 1957. 5 pp) IGO-AM/W-94

Some elevated temperature hardness measurements on magnox C alloy. *D. Shaw, P. N. Sherratt.* (May, 1957. 11 pp) IGR-TN/W-513

The oxidation of uranium in argon containing traces of oxygen. *D. Shaw, P. Hindmarch.* (April 1957. 11 pp). IGR-TN/W-517

Information bibliography: heat transfer in static granular beds. *E. McCoy, A. J. Townsend.* (May 1957. 5 pp) IGRL-IB/CA-23 1s 6d*

NAMES IN THE NEWS

GILES NEWTON

P. W. FAULKNER

The following changes in the board of The Cape Asbestos Co Ltd are announced: chairman **Mr Robert Walker** retires on August 31, **Mr Giles Newton,** deputy chairman and managing director becomes chairman and **Mr R. H. Dent** and **Mr T. C. Hale** are appointed joint managing directors. **Mr T. Muir Warden** has been appointed a member of the board.

Mr J. F. Herbert has been appointed to the newly created post of manager, overseas atomic projects, with the English Electric Company. He has also been made a director of the English Electric Export and Trading Company.

Mr T. C. Cleveland has been appointed acting manager, Export Department with E. K. Cole Ltd, he was formerly export shipping manager.

Mr E. B. Moss, technical director of Smiths Aircraft Instruments Ltd has resigned and his post will be filled by **Mr C. G. Roberts,** who was previously director of reasearch at Cheltenham.

The CEA have appointed **Mr P. W. Cash** to be system operation engineer at Headquarters. He was previously system design and development engineer.

Travelling in Expandite interests are **Mr A. E. Potter,** director, who is visiting Australia, New Zealand and India, and **Mr J. Masterson,** overseas technical representative who is to visit Libya, Belgian Congo and the Central African Federation.

Mr P. W. Faulkner, OBE, general manager of the Chemical and Metallurgical Division, The Plessey Co Ltd has been appointed an executive director of the company.

The board of Holloway Bros (London) Ltd, building and civil engineering contractors has been reorganized as follows: **Mr E. C. Uren** has been appointed chairman, **Mr W. J. Johnson,** deputy chairman and **Mr P. W. E. Holloway,** managing director.

Philips Electrical Ltd (Industrial Division) announce the appointment of **Mr J. B. Neesam** as filtration engineer and representative for the north east region.

Mr J. O. V. Christian has been appointed to the newly created post of Product Manager at Remington Rand Ltd.

Mr W. A. Flint has joined The Drayton Regulator & Instrument Co Ltd as publicity manager. Mr Flint was formerly with Electrothermal Engineering Ltd.

PATENTS

Reactor flux measurement

780,219 Improvements in nuclear reactors provided with a neutron flux measurement device. Commissariat à l'Engergie Atomique. Appn: May 17, 1954 (in France). Pubd: July 31, 1957

Measurement of low level neutron flux in a reactor is difficult partly because of gamma emission following shut-down, and partly because the measuring apparatus has to be so near the reactor that it is liable to be destroyed when the reactor starts up again. This invention aims to overcome these drawbacks by interposing between the core and the measurement device, which may be of any type, a shield, preferably of bismuth, which has a high mass coefficient for gamma rays, low neutron cross section and does not cause secondary gammas. For normal operation, when flux levels are high, a retractable shield can be interposed between the bismuth shield and the reactor. This must have a large neutron cross section and must give rise to practically no secondary gammas. Boron is the preferred material for this. The measuring instrument has two calibrations corresponding to the two positions of the retractable shield.

Lithium isotope separation

770,252 Improvements in or relating to nuclear reactors Metallgesellschaft Aktiengesellschaft, and Deutsche Gold- und Silber-Scheideanstalt Vormals Roessler. Appn: June 1, 1954 (in Germany) Pubd: March 20, 1957

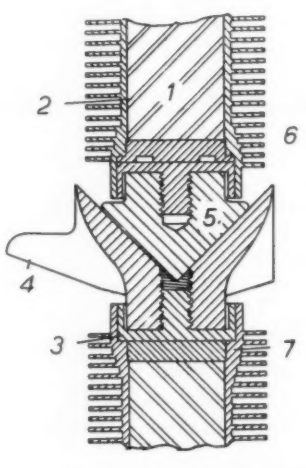
The thermal properties required of a heat transfer medium for reactors are high specific heat and thermal conductivity, low density and viscosity, low vapour pressure, high boiling point, and a capacity for absorbing and dissipating considerable quantities of heat without developing high pressure. No substance has optimum values of all these properties but lithium compares very favourably with all others. Lithium is also a good moderator and its radioactive isotopes have very short half lives. However, natural lithium contains 7% Li-6, which has a very large absorption cross section for thermal neutrons. This invention provides a transfer medium containing substantially less than 7% of Li-6 and suggests that at 0·03% by weight, the medium has neutron absorption comparable to sodium.

Apparatus suitable for reducing the Li-6 content consists of two graphite electrodes in a U-tube filled with fused lithium chloride at 650°C, with tightly packed quartz powder between the cathode and anode spaces to serve as a diaphragm. A current density of 9 amps/sq cm is passed through. Chlorine is given off at the anode and removed, and chlorine is introduced into the cathode space. Lithium chloride with a reduced Li-6 content is obtained in the anode space, while the lithium in the cathode space is enriched with Li-6.

Calder fuel element

779,408 Improvements in or relating to nuclear reactors. United Kingdom Atomic Energy Authority (inventors: R. V. Moore and G. Packman). Appn: May 11, 1954. Pubd: July 17, 1957

As in now well known, the charge in a Calder Hall fuel element channel consists of six magnesium-canned uranium bars stacked one above the other: this patent gives more details. A basic idea of the invention is the preferential cooling of parts of fuel element cans which are subject to high gravity stresses from the vertical stacking arrangement. This allows a higher temperature and greater output.



779,408 HOW THE CALDER ELEMENTS STACK
1 uranium rod 1·15 in. dia, 40 in. long
2 2½ in. dia magnesium alloy can with single start helical fin ¼ in. pitch, 1/32 in. thick
3 end cap, argon-arc welded to can
4 3-legged Mg spider
5 conical Mg boss
6 lower magnesium oxide disk ½ in. thick
7 upper magnesium oxide disk ½ in. thick, plain
Note lower oxide disk is screwed with a spanner socket and knife edge to bite into can—upper one is plain

Construction of the elements and stacking arrangements can be seen in the diagram. Build up of heat by conduction from element to element is induced by the inclusion inside the cans of a dish of magnesium oxide. In this way the parts of the fuel cartridges subjected to high stresses are kept at relatively low temperatures. Various minor alternative arrangements are included in the specification.

It should be noted that recently, owing to the so called 'Cottrell creep,' it was found that the lower elements at Calder were tending to bow in the middle. According to Sir Christopher Hinton, this has been cured by fitting some kind of additional spider in the centre of the affected elements.

An historic pile

779,134 Improvements in or relating to nuclear reactors. United Kingdom Atomic Energy Authority (inventors: F. W. Fenning and R. F. Jackson). Appn: March 25, 1952. Pubd: July 17, 1957

Very long and detailed, this is the full specification for Harwell's famous air-cooled reactor BEPO which first went critical in 1948. Since the date of application is nearly four years after the pile first went into operation the specification represents it in actuality, these being only one claim.

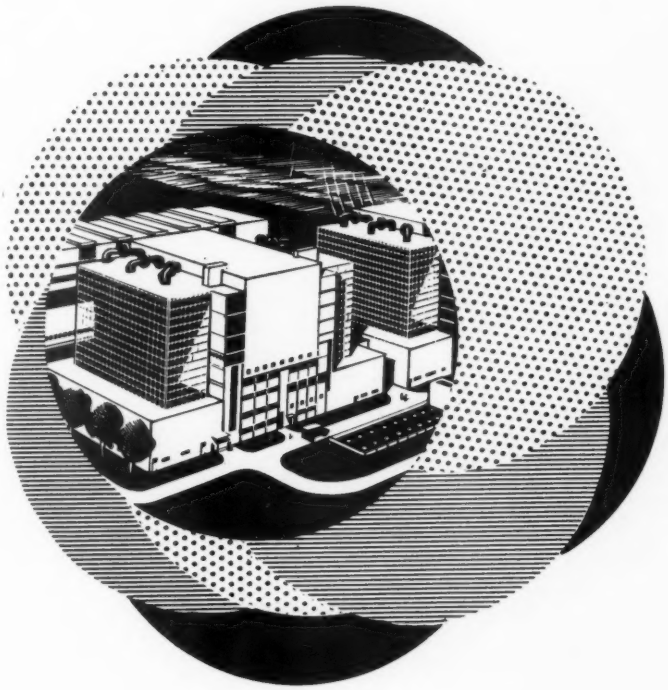
Fuel charging at Calder

772,702 Improvements in or relating to fuel element charging/discharging gear for nuclear reactors. United Kingdom Atomic Energy Authority (inventor: E. Long). Appn: June 9, 1955. Pubd: April 17, 1957

In the Calder Hall reactors, to reduce the number of standpipes through which fuel is loaded into the 1,696 core channels, the latter are grouped in 16's with a single charge tube serving each group. Since the elements thus approach the channels obliquely, means have to be provided to guide them in without damage to the graphite core or the element. The devices used at Calder to do this are known as charge guides or pans and this is the patent covering them.

The guide is a nodular iron casting with a 4 x 4 array of tapered holes corresponding with a fuel channel group. The holes are 11 in. long and taper from 5 in. to 5·92 in. dia. Support of the guides on the top of the graphite core is at three points since thermal movements of the blocks are to be expected during the reactors' lifetime. Location is centred on a 17th channel at the centre of the guide which serves the control rod hole and which also receives the snout of the charging maching The tapered holes of the charge pan are each fitted with an entry for the burst slug detection gear 'sniffer' pipes. It is stated that these guides weigh 600 lb.

These abstracts are made from British Patent Specifications with the permission of the Controller of Her Majesty's Stationery Office. Complete specifications may be obtained from the Patent Office (Sales Branch), 25 Southampton St, London, WC2, 3s. a copy (inc. postage, inland & abroad)



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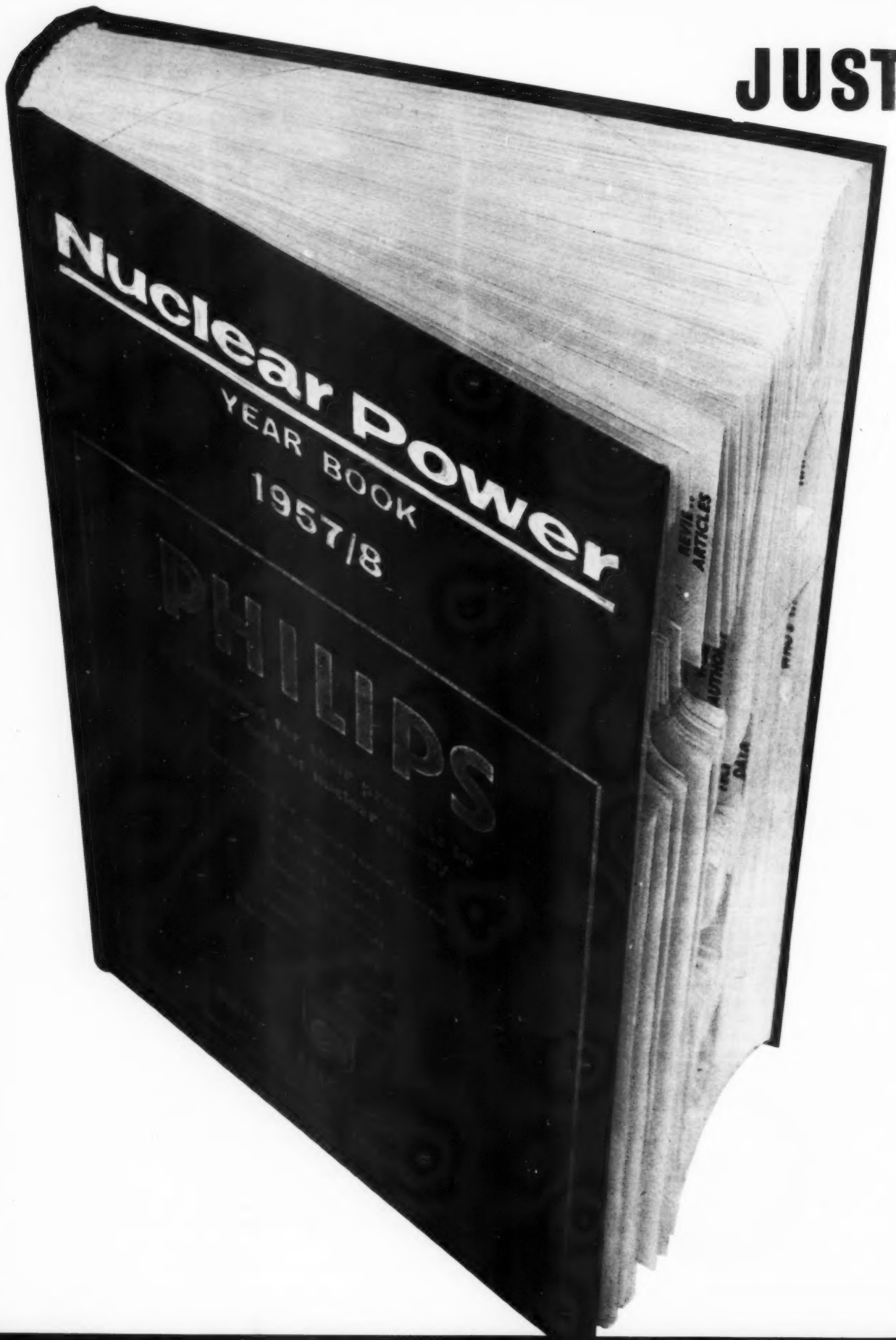
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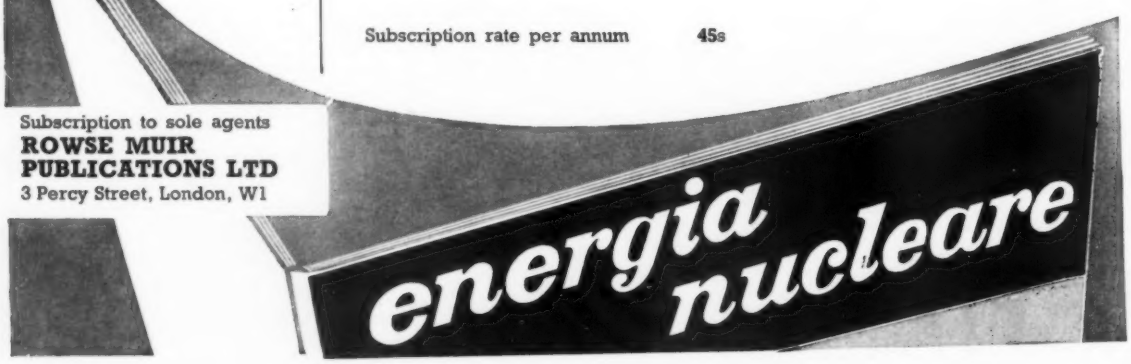

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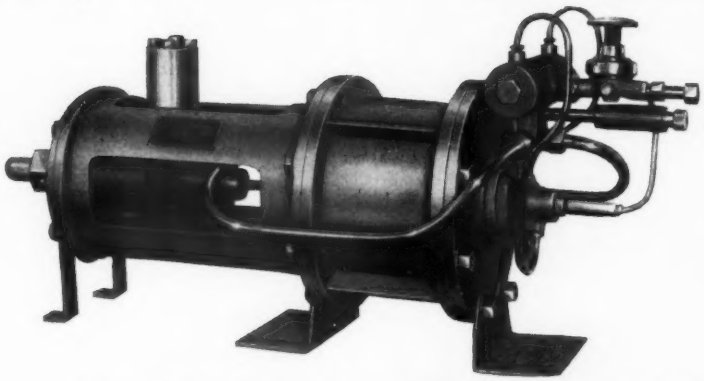

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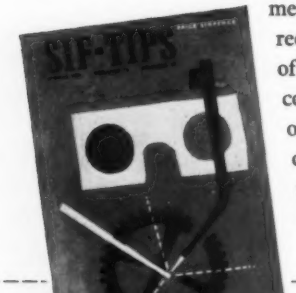

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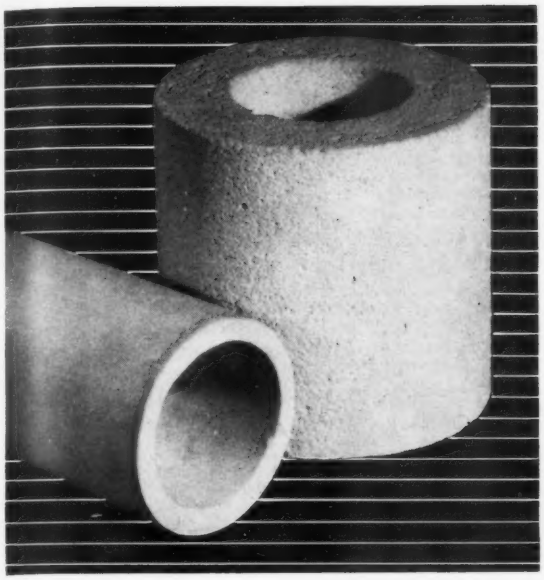

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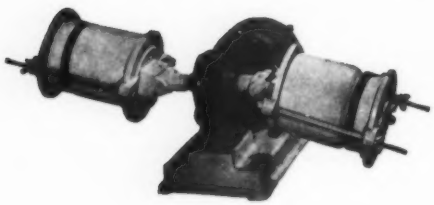

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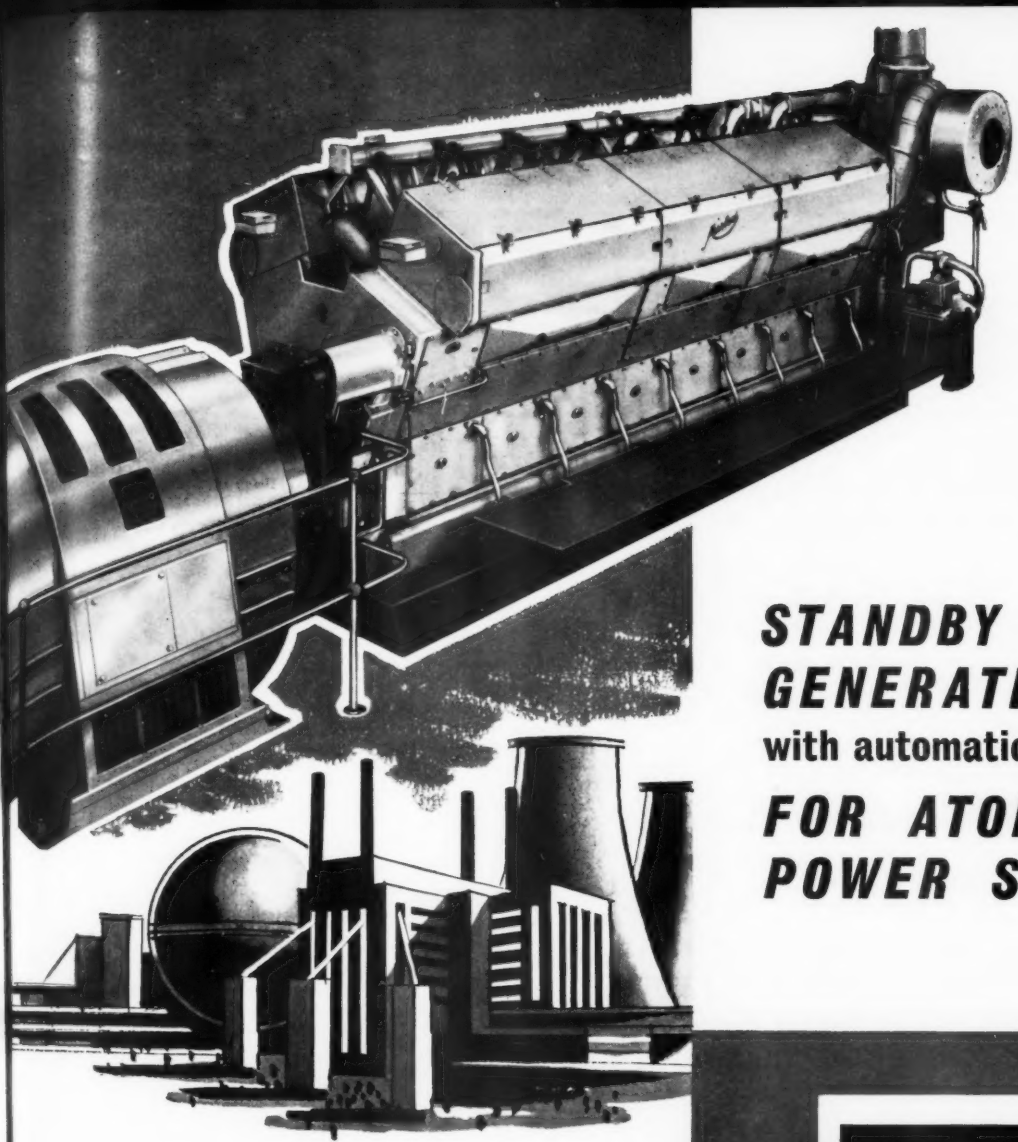

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